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1913.

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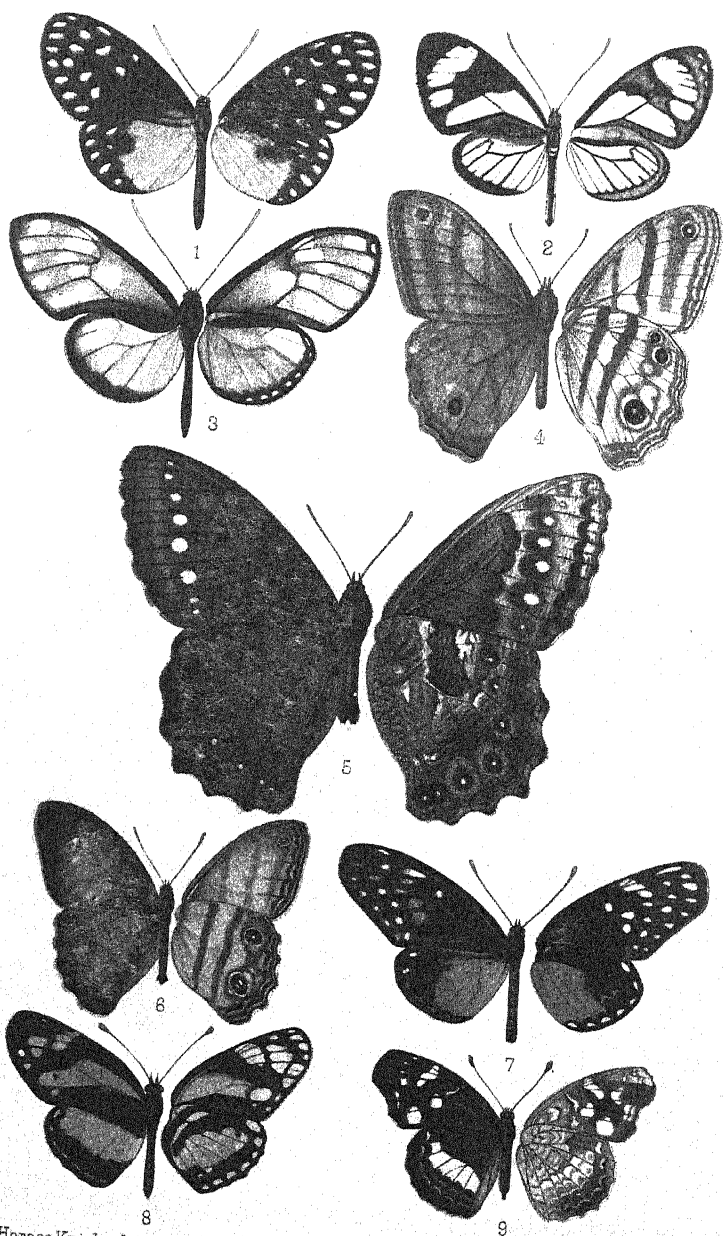
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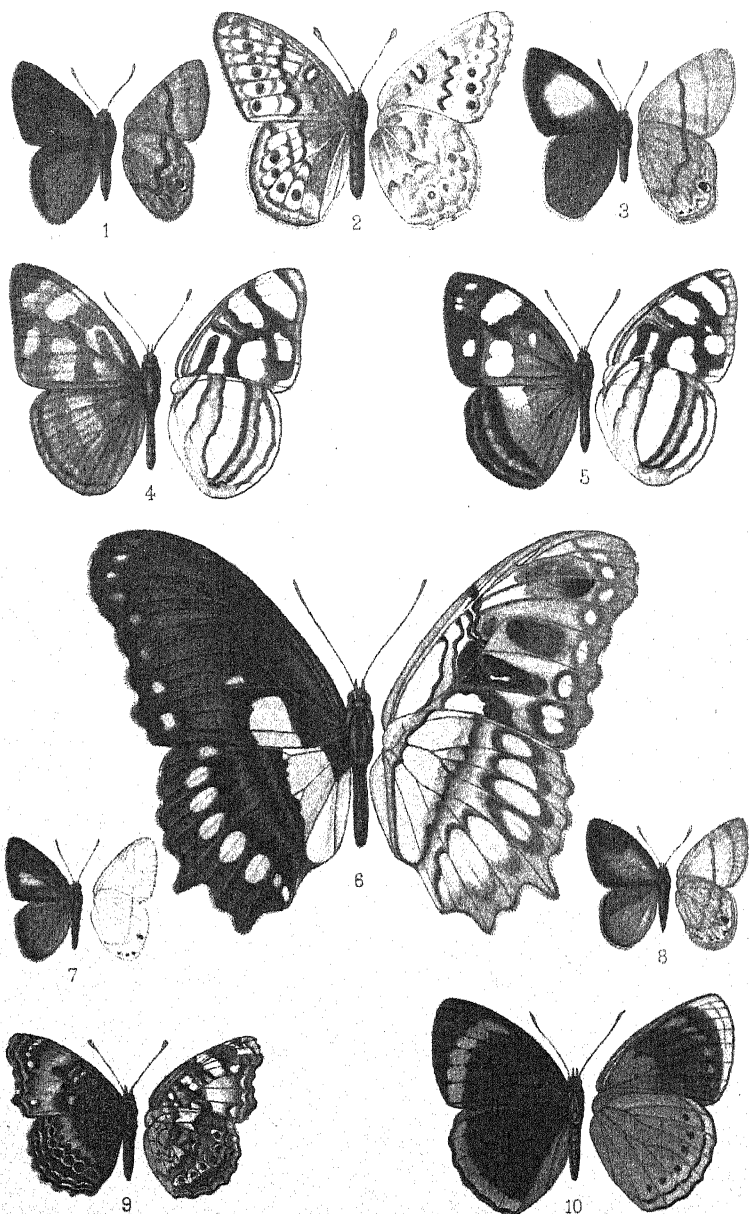


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COSTA RICAN BUTTERFLIES.

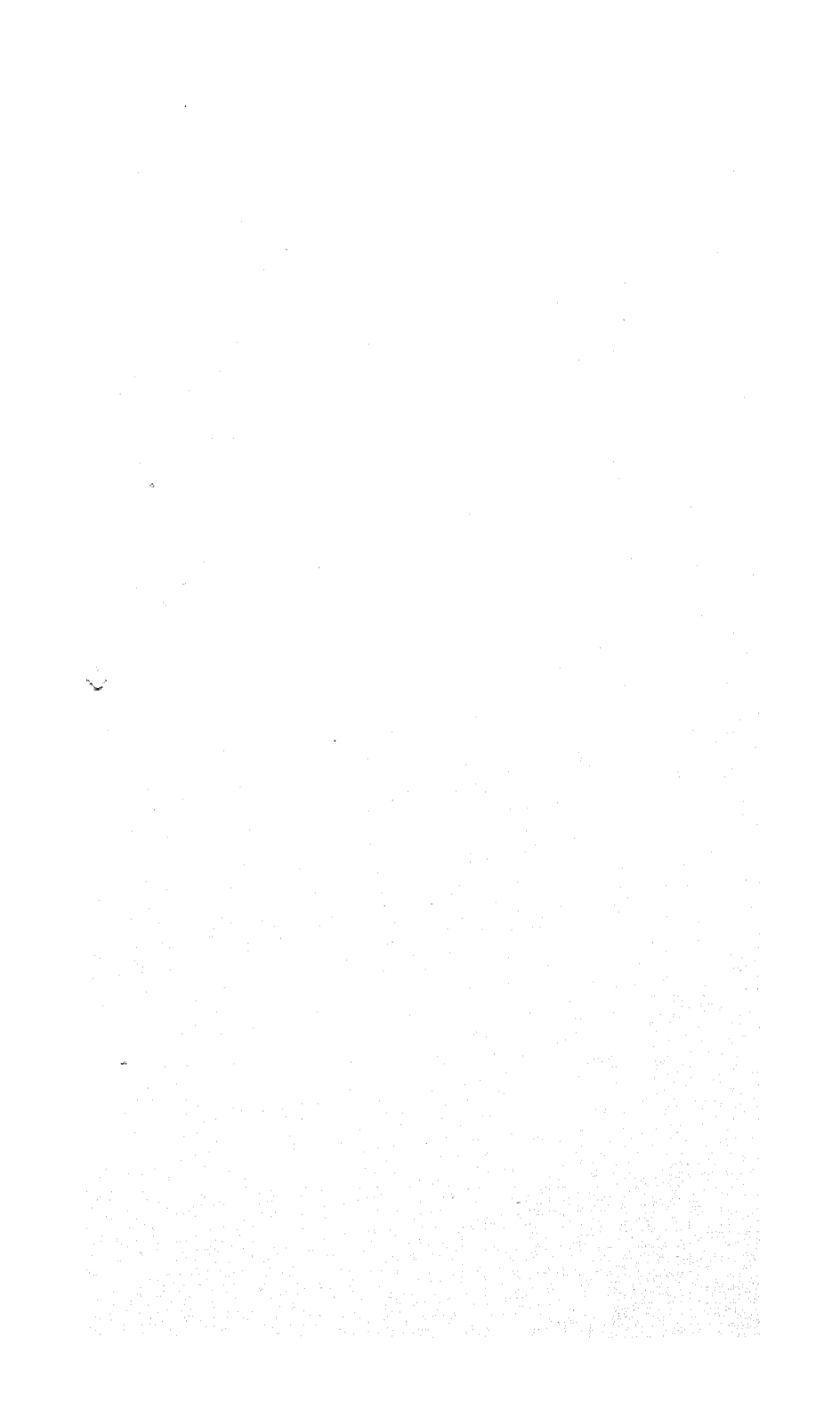


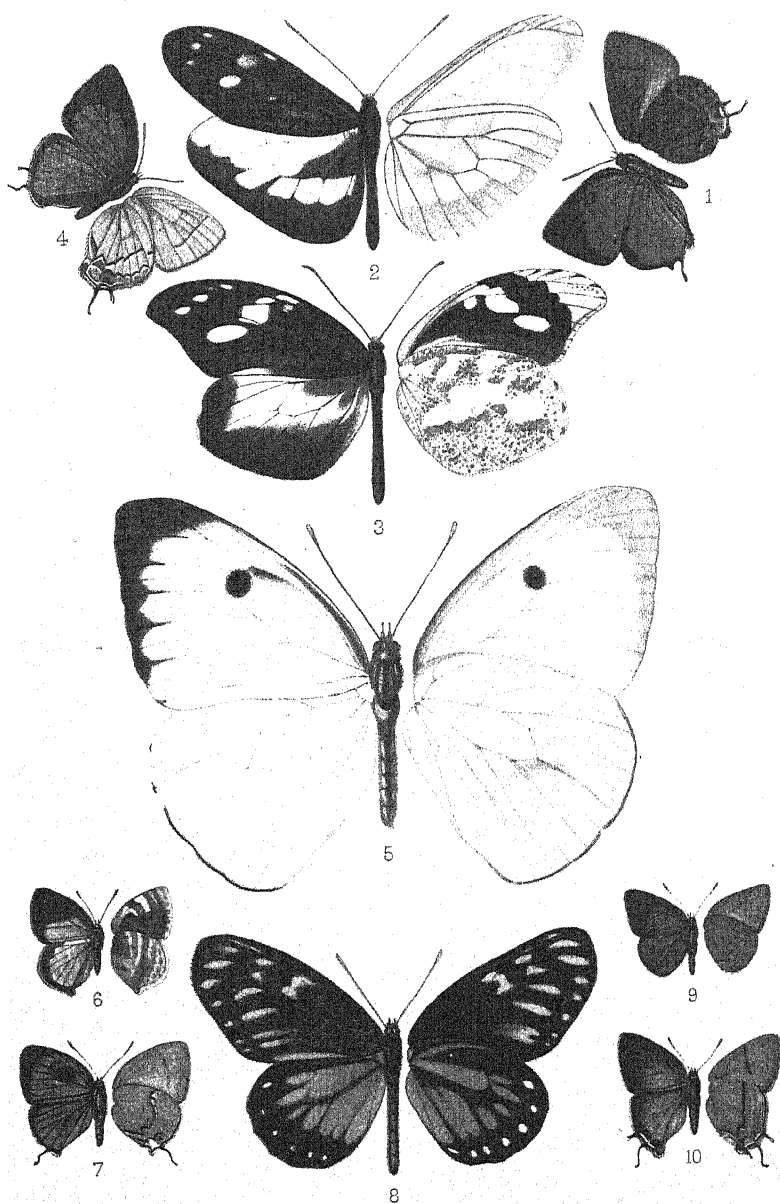


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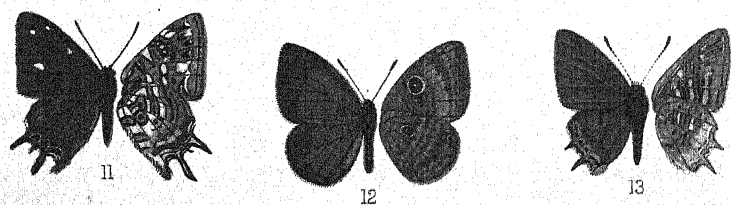
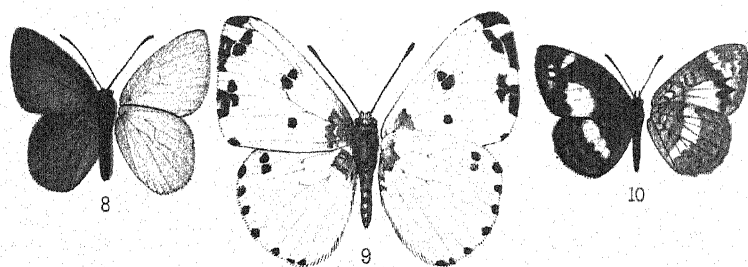
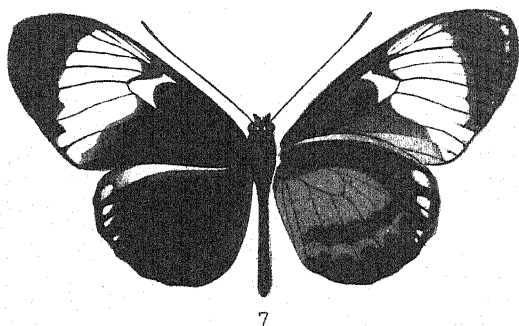
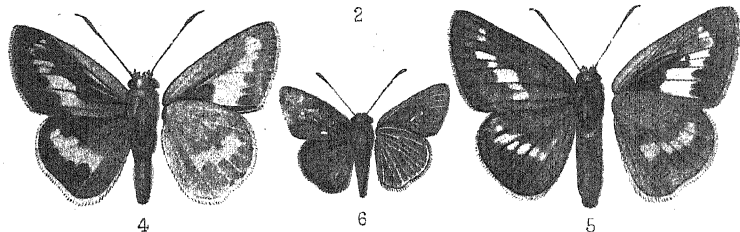
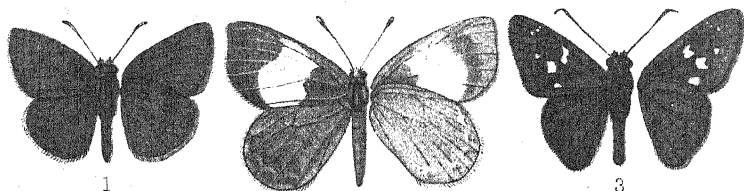


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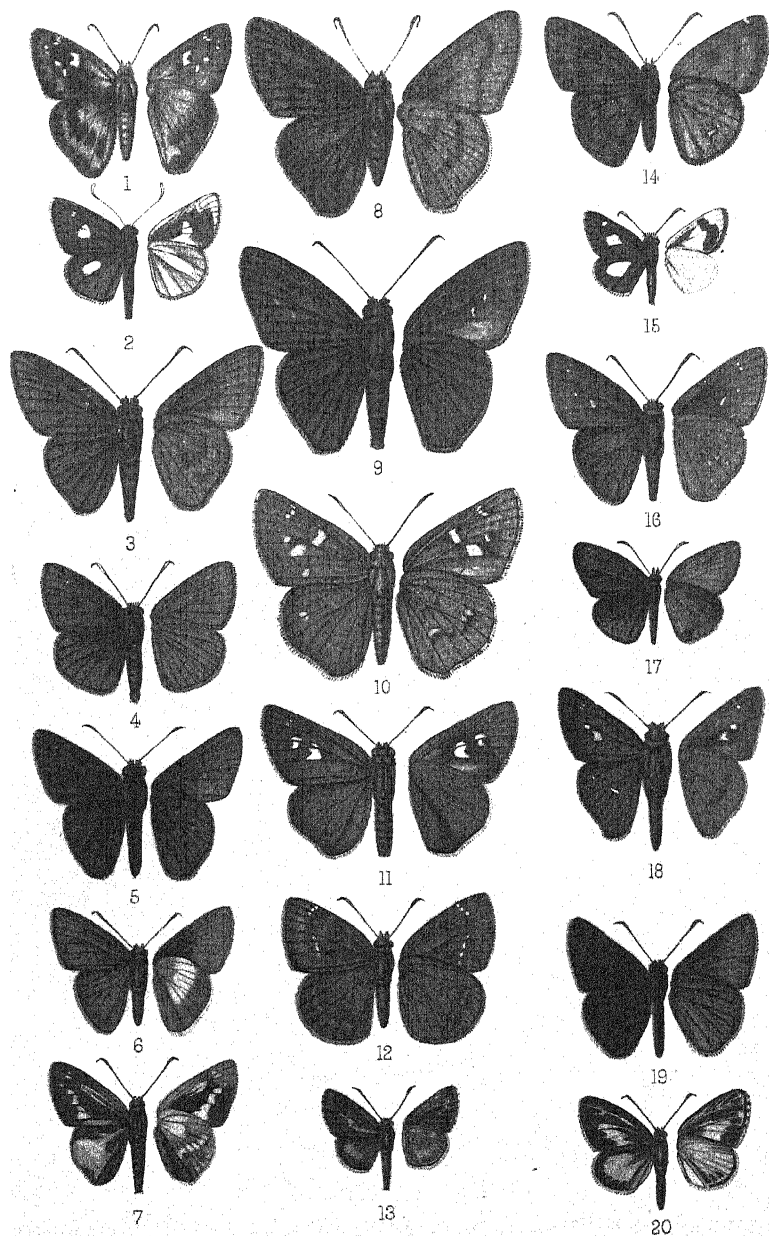


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COSTA RICAN BUTTERFLIES.

# PROCEEDINGS

OF THE

## GENERAL MEETINGS FOR SCIENTIFIC BUSINESS

OF THE

## ZOOLOGICAL SOCIETY OF LONDON.

### PAPERS.

#### 26. New Species of Rhopalocera from Costa Rica. By WILLIAM SCHAUS, F.Z.S.

[Received February 17, 1913; Read March 4, 1913.]

(Plates L.-LIV.\*)

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The following new species are the result of a recent visit to Costa Rica, where nearly three years were spent in collecting. 1081 species of Rhopalocera were taken, 409 more than were previously known from that country, and of these I am here describing 54 species as new. With the Heterocera I was equally successful, taking 4000 species, whereas only 560 are recorded in the 'Biologia Centrali-Americana' from Costa Rica, to which number 87 were added by Pittier and Biolley in Part iii. of the 'Invertabrados de Costa Rica.'

## Subfam. DANAINÆ.

## NAPEOGENES HEMISTICTA, sp. n. (Pl. I. fig. 1.)

♂. Antennæ black on basal half, apical half yellow-brown. Head black; whitish points on frons and neck behind; a white medial line on vertex. Collar and thorax black; a greyish medial line on thorax and small cluster of similar scales behind. Abdomen slate-brown above, yellow-white below. Fore wings black; basal third of inner margin and shorter shade above submedian rich brown; spots semihyaline yellowish white; two spots near end of cell obliquely placed; a spot beyond cell and an elongated spot above it on costa; an outer row of five spots, the one between veins 3 and 4 elongated, oblique; seven marginal spots, the one at apex preceded by a small elongated spot on costa. Hind wings orange-brown, the costa to discocellulars grey; apical portion beyond it black, its inner edge inbent to vein 3 or before it, then outbent to near margin, which becomes narrower, the black not reaching anal angle; five marginal spots; subterminal spots above and below vein 5, sometimes almost obsolescent. Wings below similar; no brown at base of fore wing; the costa of hind wing black.

Expanse 54 mm.

Hab. Carrillo, Guapiles.

In British Museum.

*PTERONYMIA FUMIDA*, sp. n. (Pl. L. fig. 3.)

♂. Antennæ black, apical fourth orange. Head and thorax black-brown; a white circle around eyes. Abdomen dark slate-brown; a whitish vertical line below terminally. Fore wings semihyaline smoky black, the veins, costal margin, inner margin to median, and termen narrowly brown-black; faint yellowish spots, one at end of cell close to median; an outangled post-medial series of spots, the one between veins 2 and 3 elongated, suffusing with the lowest of marginal spots, of which there are five. Hind wings reddish brown, semihyaline, the margins black, more broadly so on outer margin, the inner margin very finely black; traces of a yellowish subterminal shade at apex. Wings below duller; two white spots at apex of fore wing; marginal white spots on hind wings, paired on interspaces.

Expanse 57 mm.

*Hab.* Carillo.

*PTERONYMIA GODMANI*, nom. nov.

This form is the *Pteronymia simplex* of the Biologia, but not *P. simplex* Salv.; the discocellular line is narrow and curved; apex of hind wings below usually without spot, sometimes one, never two as in *P. simplex* Salv.

Found generally in Costa Rica above 3000 ft.

*ITHOMIA BOLIVARI*, sp. n. (Pl. L. fig. 2.)

♂. Head black spotted with white. Collar dark reddish brown. Thorax black shaded with grey. Abdomen black above, ventrally white. Fore wings black; the cell to near end, which is filled by the broad oblique fascia from costa, the space between veins 2 and 3 to near termen, a large terminal spot between 2 and 3, and a subapical fascia from costa to vein 3 hyaline, the fascia mostly shaded with white. Hind wings hyaline, the veins and outer margin narrowly black; the costa grey-black. Fore wings below: inner margin fuscous grey; dark spaces brown edged with black, more broadly in cell and at apex; base of costa black; 4 apical white spots, the one on costa minute. Hind wings below: margins brown edged with black; a broad yellow streak at base of costa; veins black; small paired whitish spots on three interspaces below apex.

Expanse 43 mm.

Generally distributed along the Caribbean coast.

In British Museum.

## Subfam. SATYRINÆ.

*EUPTYCHIA DRYMO*, sp. n. (Pl. L. fig. 6.)

♂. Body and wings dark brown, the disc of wings lighter brown, especially on fore wings; the two lines of underside faintly indicated; a terminal black line, preceded by a faintly greyish shade, and fuscous marginal line; a subterminal fuscous

wavy line on hind wings. Fore wings below yellowish buff; the two lines bright reddish brown, vertical, the inner line not reaching costa; costal margin shaded with grey; a subterminal dull brown shade interrupted by an ocellus below costa, black, circled with yellow, and containing a bluish-white point; the termen greyish crossed by two fine lines, faintly wavy, and a terminal fuscous line. Hind wings below lilacine grey tinged with pale buff; the two lines parallel, slightly inbent; a large ocellus near apex, surmounted by a very small ocellus, and with a yellow spot below it; a large ocellus between veins 2 and 3, containing two bluish points with a yellow spot above it, outwardly broken; the ocelli edged and connected by a dull brownish shade; termen grey, the two marginal lines more deeply wavy, shaded with reddish brown at anal angle; a terminal fuscous line.

Expanse 37 mm.

*Hab.* Guapiles.

Near *E. confusa* Stgr., and *E. labe* Butl.

In British Museum.

*EUPTYCHIA AGNATA*, sp. n. (Pl. L. fig. 4.)

♂. Wings brown; traces of antemedial and medial darker lines. Fore wings: an even marginal darker shade, faintly darker edged; the apical spot of underside faintly indicated. Hind wings: a large subterminal fuscous spot between veins 2 and 3; the apical spot of underside indicated; subterminal, marginal, and terminal darker lines. Wings below pale grey; the antemedial and medial lines dark reddish brown. Fore wings: the two lines vertical; a broad darker brownish-grey outer shade; the apical ocellus black, edged with yellow and containing a black point; dark subterminal and marginal lines; a fine fuscous brown terminal line. Hind wings: the two lines slightly inbent, the outer one angled near inner margin; ocelli black, broadly edged with yellow and containing a white point; darker grey shading around ocelli; a small ocellus at apex above vein 6, and a large one below it; a small yellow spot below vein 5; a larger yellow spot below vein 4 suffusing with the large ocellus below vein 3; the subterminal and marginal lines dark brownish grey, becoming reddish brown on inner margin; terminal line fuscous brown.

Expanse 48 mm.

*Hab.* Guapiles.

Near *E. antonoë* Cramer, found in the same locality and *E. juani* Stgr.

*CATARGYNNIS DRYADINA*, sp. n. (Pl. L. fig. 5.)

♂. Body fuscous, clothed with brown hairs; a white lateral streak on palpi. Fore wings brown; a vertical outer row of white spots on interspaces, broadly edged with darker brown, the spots on costa and at submedian fold smaller, followed throughout by a broad lighter brown shade, and preceded by a

similar triangular shade between veins 5 and 6. Hind wings darker, especially terminally; an outer row of small white spots on interspaces; cilia partly white on interspaces. Fore wings below dull olive-brown to beyond cell, its outer edge outcurved from costa, uneven; outer third pale buff shaded with dark grey; the white spots as above broadly edged with dull dark brown; a broad subterminal fuscous brown line, lunular between veins 5 and 7, obsolescent on costa; some fine dark striae on apex; a terminal interrupted fuscous brown shade. Hind wings below dull olive-brown, mottled with white antemedially and beyond medial fascia, crossed by darker striae; the medial fascia defined by darker edging, broad, outbent in cell to end, downbent towards inner margin; the small outer white spots broadly edged with fuscous brown, preceded and followed by fuscous brown shadings; the outer margin deeply crenulate from vein 4 to anal angle, less so towards apex.

Expanse 72 mm.

*Hab.* Volcano Turrialba, at 8000 feet.

Subfam. HELICONINÆ.

*HELICONIUS GALANTHUS*, ab. *SUBRUFESCENS*, ab. nov. (Pl. LIII. fig. 7.)

Differs from *H. galanthus* Bates on the underside of hind wings; the medial space below subcostal black, the fascia being reddish brown, limited by a postmedial broad black line, followed by a narrow brown shade having its outer edge incurved on interspaces. In *H. galanthus* the medial space is black edged above and below with reddish brown.

A single specimen taken on the slopes of Turrialba. Belongs to the group with greyish costa on hind wings.

Subfam. NYMPHALINÆ.

*EUPETOIETA POASINA*, sp. n. (Pl. LI. fig. 2.)

♀. Wings brownish buff. Fore wings: the base olive-brown irrorated with black; an antemedial black line in cell, and one below it, outset; a pale spot near end of cell, broadly edged with black; postmedial line black, oblique from costa, inbent, lunular below vein 4, angled on veins, followed by a straighter, narrower, fuscous line; an outer row of black spots on interspaces, suffusing on costa with subterminal fuscous line, which is lunular, inwardly toothed on veins; termen fuscous, with a pale interrupted lunular marginal line. Hind wings: base darker brown with a black line on discocellular, limited by the black medial line, which is incurved opposite cell, angled at vein 4, followed by a fuscous straighter line; a black shade at base and below cell; four outer black spots between veins 2 and 6; subterminal line lunular from veins 6 to 3, otherwise straighter; the pale marginal line broader. Fore wings below light brown to postmedial; an antemedial black line in cell; the cell spot paler edged with

black except on subcostal; space beyond postmedial brownish buff, the costa and termen shaded with greyish green; outer spots below veins 2, 3, and 4; on costa a dark shade, inset and preceded by some white; subterminal line brown. Hind wings below mottled brownish buff and dull green, the veins and termen whitish grey; a curved antemedial whitish line above cell; medial line fine, fuscous, inwardly edged with whitish grey; subterminal line fine, brown, outwardly edged with whitish; cilia white with brown points at veins.

Expanse 46 mm.

*Hab.* Poas.

In British Museum.

*ERESIA STICTA*, sp. n. (Pl. L. fig. 7.)

♂. Antennæ black tipped with yellow. Head, collar, and thorax black; a white streak on palpi; two white spots on frons, and one on vertex. Abdomen brown above, laterally irrorated with white; underneath white with a ventral black line. Fore wings black, the spots yellow-white, partly greyish; a round spot at end of cell; postmedial streaky spots from costa to vein 4, outcurved, and two spots between 2 and 4, inset, vertical; outer and marginal spots, both slightly inset between veins 3 and 4, the marginal spot obsolescent at apex. Hind wings reddish brown; a black shade along subcostal, expanding from middle of wing, forming a broad margin, narrowing to anal angle; marginal white spots at apex. Fore wings below: the spots larger, yellow-white; some brown shading at base of inner margin. Hind wings below similar, but the costa also black with a short yellow streak at base; large marginal white spots.

♀. Antennæ yellow except at basé; a brown streak below cell on basal half. Hind wings with the margin much more narrowly black, and no black shading on subcostal, except subterminally; marginal white points from below the apical spots. Hind wings below: the costa broadly black; a short yellow streak at base; traces of fuscous subterminal spots; the marginal spots triangular.

Expanse, ♂ 53 mm., ♀ 60 mm.

Some males have the costa of hind wings entirely black; the species is allied to *E. pæcilina* Bates, but the apex is more bluntly produced, and the termen more oblique.

In British Museum.

*ERESIA CÆLA* Druce. (Pl. L. fig. 8.)

♀. Ent. Monthl. Mag. xi. (1874) p. 37, fig.; B. C.-A. Lep. Rhop. vol. i. p. 187 (tab. xxi. figs. 2, 3).

♂. Fore wings black; a reddish-brown fascia through entire cell, downbent between veins 2 and 3 to near termen, with a small black spot on it close to vein 3 postmedially, and shaded with yellowish terminally; a small subterminal reddish-brown spot just below vein 2; an oblique paler fascia postmedially from



costa to vein 5, and large subterminal spots between 4 and 6; a small round marginal spot, tinged with whitish above vein 4, and one below it. Hind wings black; a broad reddish-brown fascia from inner margin to near apex; a similar marginal line, interrupted by veins, the apical spot paler. Underneath similar to female, but all the spots yellow instead of white; the brown fascia on fore wings brighter brown, separated by a black line from the large subterminal spot. Hind wings below with the fascia as above but tinged with yellow, otherwise agreeing in markings with the female.

Expanse 45 mm.

Found on the Caribbean coast only.

*PHYCIODES DORA*, sp. n. (Pl. LI. fig. 9.)

♀. Palpi dark brown, whitish grey below. Head dark brown. Body fuscous with fine yellowish irrorations. Fore wings: basal half black, its outer edge projecting between veins 4 and 5, and less so outcurved between vein 2 and submedian, followed by a yellow shade from costa to vein 4, and a yellow spot between veins 2 and 3; the base with some yellowish irrorations, leaving a geminate antemedial outbent line clear black; two yellowish-brown spots across end of cell, suffusing; a reddish-brown line on discocellular; a medial small yellow spot above submedian; outer half bright brown, irrorated with black subterminally, interrupted by round yellow spots edged with black, one below vein 2 and another between 4 and 5; three smaller yellow spots from above vein 6 to costa; termen fuscous preceded by a sinuous yellow-brown line. Hind wings black irrorated with yellow-grey, leaving clearer black lines on basal third; a brown line on discocellular; a postmedial bright brown fascia from costa to vein 2; large outer spots formed by yellow edging, inwardly rounded, outwardly straight; these spots fill the entire interspaces; a subterminal wavy yellow line; a terminal yellow line at anal angle. Fore wings below brighter, the base greyish; a yellow-grey shade between the antemedial black lines; the cell spots broader forming a band: the yellow shades beyond dark space more extended; the termen brown; a grey shade at apex. Hind wings below: base to medial grey-brown, darkest in cell, whitish lilacine above cell; a subbasal and an antemedial lunular brown line, partly followed by the other less distinct lines; the medial line dark brown, inbent on vein 4, outset between vein 2 and submedian; postmedial space dull brown followed by a series of spots, except on costa, the spot above vein 4 round, fuscous brown, the spot below 4 triangular, the others more lunular, mostly edged with geminate lilacine lines; a subterminal geminate lunular dark brown line; termen lilacine white from apex to below vein 6, then dark brown, shaded with still darker brown between spots and lunular line.

Expanse 39 mm.

*Hab.* Poas.

## PHYCIODES PHLEGIAS G. &amp; S. (Pl. L. fig. 9.)

♂. B. C.-A. Lep. Rhop. vol. ii. p. 680 (tab. cviii. figs. 21, 22).

♀. Body and wings above fuscous brown, the body and base of wings irrorated with ochreous. Fore wings: spots white; an oblique line across cell near end, followed by a large white spot between veins 2 and 3, and a few white scales above 3 and below 2; a postmedial oblique broad white line from costa to vein 4; a small outer spot on costa; a quadrate spot between veins 4 and 5, and a larger spot above submedian, extending just above vein 2; traces of small whitish spots between veins 5 and 7; traces of a fine outcurved subterminal line, broad and well marked from vein 4 to near vein 2. Hind wings: a broad postmedial white fascia from vein 7 to inner margin, followed below vein 4 by a line of ochreous irrorations; subterminal line slightly lunular, fine, white on costa, then ochreous. Fore wings below: base and costa mottled pale brown and grey; a broad antemedial fascia defined by edging of dark outcurved lines; the white line at end of cell downbent to inner margin; the space between postmedial and outer spots fuscous; apex lilacine grey; a broad terminal dark brown shade between veins 4 and 6; termen more narrowly brown at tornus; subterminal line fuscous brown. Hind wings below lilacine grey, broadly shaded with white postmedially between veins 2 and 7; basal half crossed by fine brown lines; the postmedial better defined, incurved on costa, and followed there by a brownish shade; a fine lunular outer line, with a series of faint greyish spots beyond it; subterminal line geminate, lunular, filled in and preceded by a dark grey shade from vein 7 to vein 2; termen dark brown from above vein 5 to below vein 2.

Expanse 39 mm.

*Hab.* Peralta.

## PHYCIODES NIVEONOTIS Btl. &amp; Druce. (Pl. LIII. fig. 10.)

♂. Cist. Ent. i. (1872) p. 100, fig.; B. C.-A. Lep. Rhop. vol. i. p. 200 (tab. xxi. fig. 27).

♀. Body above fuscous. Wings fuscous brown. Fore wings: a large white spot just beyond middle from submedian to near vein 2, edged with yellow-brown, irrorated with black; the outer broad white line from costa to vein 5 similar; small subterminal similar spots between wings 4 and 6, and a yellow-brown spot below vein 4. Hind wings: a yellow-brown line on discocellular; a line of similar irrorations beyond postmedial fascia which has its edge also finely yellow-brown; subterminal line brownish, faintly indicated towards inner margin. Fore wings below light brown; an antemedial fascia defined by dark lines; two whitish spots near end of cell; a brown spot on discocellular edged with black; a broad black postmedial shade from costa, outcurved to near tornus; a subterminal lunular dentate darker brown line; the spots all whitish. Hind wings below: base grey-brown crossed by brown lines; the whitish fascia obscured by brown

irrorations and crossed by a fine line; outer margin broadly brownish, irrorated partly with grey; an outer row of fuscous grey spots on interspaces; a marginal lunular dark brown line.

Expanse 30 mm.

*Hab.* Juan Vinas.

*EUBAGIS HECUBA*, sp. n. (Pl. LI. figs. 4, 5.)

♂. Body above fuscous, whitish underneath. Wings bluish green. Fore wings: apex and outer margin black, expanding at vein 4, its inner edge obliquely outbent to vein 2, below which it is very finely black. Hind wings: a marginal and a terminal black line, suffusing at apex. Wings below white. Fore wings: costa grey-brown with a white streak at base; subcostal medially red-brown; a fine blue line and red-brown streak below subcostal to beyond cell; a red-brown streak on discocellular, edged with metallic blue and then black; a broad medial black fascia from end of cell, and an antemedial black fascia inbent across cell, interrupted by median and narrowest below it; a broad black line above vein 3 from cell, to a similar oblique line which extends from costa to brown terminal space; another black line from vein 3 is obliquely downbent to a black tornal space; the tornus itself whitish; the termen from vein 2 to just above vein 6 reddish brown, its inner edge fuscous, upbent to costa, leaving a white apical space. Hind wings: lines reddish brown partly edged with fuscous; an inbent basal line; a medial fascia expanding to close to inner margin, and then downbent, enclosing a white space from subcostal; a broad subterminal line, its outer edging downcurved near apex, forming a marginal fuscous line partly mottled with reddish brown; anal angle reddish brown where all the lines suffuse; some metallic blue scaling near anal angle.

♀ similar below. Fore wings above green; a white spot in cell above vein 2; a black shade below subcostal expanding at end of cell, followed by a large postmedial white spot oblique from costa to just below vein 4; a large postmedial vertical spot between submedian and vein 3; outer margin broadly black; a subterminal small white spot between veins 2 and 3, and smaller spots above and below vein 5, also a small inset spot near costa. Hind wings green; a postmedial broad white space from costa to below vein 5; a broad black subterminal line, and a similar marginal line; the termen brown-black with a fine green line near anal angle, the lines all suffusing in a brown shade at apex.

Expanse, ♂ and ♀ 40 mm.

*Hab.* Carillo. Guapiles.

Allied to *E. vicaria* Bates.

In British Museum.

*PERISAMA BARNESI*, sp. n. (Pl. LI. fig. 10.)

♀. Palpi black broadly streaked with white. Body black above, some white scaling around the eyes. Wings black. Fore

wings: some dark blue irrorations at base, along veins, and in cell; a postmedial curved greenish-blue fascia from costa to tornus, its edges uneven. Hind wings: some scattered blue irrorations; the outer margin greenish blue; a terminal brown-black line; cilia white. Fore wings below black; the cell to near end and a space below it crimson; a postmedial curved series of metallic blue spots; termen white, broadest at apex, crossed by a fine marginal black line. Hind wings below grey-brown shading to whitish on termen; costa narrowly crimson; outer small round black spots on interspaces; a subterminal and a terminal dark brown line.

Expanse 43 mm.

*Hab.* Carillo.

This species is named after J. Barnes, who captured the only specimen met with.

This is the first *Perisama* recorded from Central America.

VICTORINA STENELES, ab. STYGIANA, ab. nov. (Pl. LI. fig. 6.)

♂. Fore wings fuscous brown, darkest medially; a large pale green spot on inner margin close to middle, almost reaching vein 2; a very small outset spot above vein 2; a small white spot medially on costa; subterminal whitish spots, larger and better defined near tornus. Hind wings fuscous brown; base darker followed by a broad pale green fascia and a medial fuscous fascia, all stopping at submedian; the inner margin white; an outer row of oval green spots on interspaces preceded by fuscous shadings; veins terminally darker edged. Underneath more like the typical form.

Expanse 82 mm.

*Hab.* Avangarez.

#### FAM. ERYCINIDÆ.

EURYGONA MYSTICA, sp. n. (Pl. LI. fig. 8.)

♀. Palpi white. Frons white divided by a brownish line. Vertex black. Collar and thorax brown. Abdomen above brighter brown, underneath white. Fore wings fuscous brown: the cell and basal half of wing below it bright brown; a paler rust-brown shade between veins 2 and 4, not reaching outer margin. Hind wings rust-brown, the costal margin broadly fuscous brown. Wings below pale brownish grey, the postmedial line vermilion finely edged with dark grey. Fore wings: the postmedial line slightly outbent, straight; a subterminal narrow vermilion shade; a terminal yellow-brown shade. Hind wings: the postmedial line vertical to below vein 2, then curved and wavyly indented to inner margin; a subterminal lunular dentate brownish shade from costa to below vein 3, followed by marginal points between veins 4 and 7, between 3 and 4 by a large black spot outwardly edged with white; below vein 2, irregular brown

lines terminating in black points followed by white shading; termen from above vein 2 to anal angle vermilion.

Expanse 22 mm.

*Hab.* Rio Grande, San Mateo.

*EURYGONA LEUCON*, sp. n. (Pl. LI. figs. 1, 3.)

♂. Palpi, lines on frons and tarsi pale buff. Head fuscous. Thorax and base of abdomen dark brown, abdomen otherwise bright brownish red above; underneath greyish buff. Fore wings faintly angled at vein 4, fuscous; a brown-red shade at base from cell to inner margin; a similar streak at base below subcostal. Hind wings brownish red; the costal and outer margins to vein 2 black, the inner margin fuscous brown. Wings below pale greyish brown, the medial line brownish red finely edged with black. Fore wings: medial line slightly angled at vein 4, terminating at submedian fold; an outer vertical dark brown line, not so well marked. Hind wings: the medial line incurved between veins 4 and 2, deeply downcurved below 2; subterminal greyish lunules from costa to vein 4, edged with dark brown; between 4 and 3 the lunule is larger, yellowish, followed by a black spot, outwardly edged with white; the inner brown shading expands between 3 and 2, and is followed by a dark wavy line; from vein 2 to inner margin are three yellow-brown streaks outwardly irrorated with black and terminating in white points before a fine marginal fuscous line; cilia reddish brown except at apex.

♀. Fore wings fuscous; a large orange space from middle of cell and well beyond it, not reaching costa, or below vein 2. Hind wings dark brown; the outer margin outcurved from veins 4 to 2, shaded terminally from 4 to anal angle with brownish red. Wings below light yellow-brown, the medial line as in male, but brighter red; the outer line on fore wings also red; the lunules on hind wings heavier, geminate, the marginal shadings faintly marked.

Expanse, ♂ 26 mm., ♀ 29 mm.

*Hab.* Turrialba.

*EURYGONA LEUCOPHRYNIA*, sp. n. (Pl. LIII. fig. 8.)

♂. Frons white. Vertex and body fuscous; some brown shading on abdomen dorsally. Wings brown. Fore wings: costal margin, front of cell, apex, and outer margin more narrowly tinged with fuscous. Hind wings: costal and inner margins greyish; a subcostal fuscous shade. Wings below silvery white.

Expanse 27 mm.

*Hab.* Cachi.

Near *E. catalaueca*, but larger and brighter brown.

*EURYGONA MATUTA*, sp. n. (Pl. LI. fig. 7.)

♂. Frons white. Vertex and body above fuscous brown, underneath white. Fore wings fuscous, the base in and below cell

shaded with brown; an orange wedge-shaped spot close to cell, between veins 2 and 4. Hind wings brown, the outer margin shaded with fuscous; the costa whitish; the inner margin grey-brown; cilia on inner margin and apex white. Wings below white; a very fine pale olive-brown postmedial line, almost vertical, bluntly curved below vein 2 on hind wings. Hind wings: a small black marginal spot between veins 3 and 4; three black points from vein 2 to inner margin, and a few subterminal black irroration.

Expanse 21 mm.

*Hab.* Juan Vinas.

*MESOSEMIA ALBIPUNCTA*, sp. n. (Pl. LIII. fig. 12.)

♂. Thorax and base of abdomen metallic blue, abdomen otherwise and head fuscous; underneath grey. Wings vivid blue. Fore wings: a white point near end of cell; outer margin broadly black, widest on costa, its inner edge outbent and curved near tornus. Hind wings: termen black, the veins close to it streaked with black; a subterminal black spot at apex, suffusing with black costal margin; in another specimen the spot continues as a line to inner margin. Wings below grey-brown, the lines darker brown. Fore wings: the two lines before ocellus parallel, outbent from subcostal; ocellus large, a white central point, and two outer points, circled with yellow; two lines beyond ocellus, close together, diverging slightly towards inner margin; postmedial space grey irrorated with metallic blue from near costa to vein 3, limited by a fine greyish yellow line, outbent from costa, at submedian approximated by a similar subterminal line. Hind wings: the antemedial and postmedial lines straight, geminate; the medial shade partly linear interrupted by a smaller ocellus, black, circled with yellow and containing two white and blue points; a broad outer shade; a subterminal line; termen dark shaded.

Expanse 27-30 mm.

*Hab.* Guapiles, Esperanza.

*HERMATHENA OWENI*, sp. n. (Pl. LIII. fig. 9.)

♂. Head and thorax black clothed with greyish-white hairs. Abdomen grey, with transverse black segmental shades. Wings white, the base mottled with black with traces of a subbasal whitish line; spots black, two beyond cell; a medial spot below vein 2; subterminal quadrate spots above and below vein 6, also above and below vein 3; apex black; spots at end of veins; terminal interspaces between veins 2 and 3, and 4 and 6 mottled with black. Hind wings: terminal spots at veins; subterminal quadrate spots above and below vein 7. Underneath similar; the basal mottling showing through from above; the terminal markings on interspaces entirely black.

Expanse 42 mm.

*Hab.* Costa Rica.

Named after Prof. Owen of Madison, Wis., who has kindly given me this unique specimen.

## CORRACHIA, gen. nov.

♀. Fore wings: outer margin straight at apex, then rounded; vein 3 close to lower angle of cell; 4 from lower angle; discocellular incurved, slightly oblique; 5 from just above middle; 6-10 stalked from upper angle, 10 before 6; 11 from close to end of cell anastomosing with costal vein. Hind wings as long as fore wings; cell elliptical; vein 3 before end; 4 from end; 5 from middle of discocellular; 6 and 7 stalked. Abdomen stout.

Type of genus, *C. leucoplaga* Schaus.

## CORRACHIA LEUCOPLAGA, sp. n. (Pl. LIII. fig. 2.)

♀. Body and wings brownish slate-colour. Fore wings: a broad medial white fascia, slightly outcurved, from subcostal to submedian vein, a whitish streak on costa above it between veins 10 and 11. Hind wings: marginal fuscous lunules, faintly edged with greyish. Wings below grey. Fore wings: the white fascia followed by a broad outcurved fuscous shade to some whitish subterminal points. Hind wings: termen irrorated with whitish; small subterminal fuscous spots preceded by whitish shadings.

Expanse 35 mm.

*Hab.* Palmital.

This peculiar species will probably be found to have a very dissimilar male.

## CHARIS SUBTESSELLATA, sp. n. (Pl. LIII. fig. 11.)

Body above fuscous. Fore wings fuscous, the base tinged with olive-brown; a white spot in cell; an outer white spot between veins 2 and 3, and a smaller one between 5 and 6; a small post-medial spot above vein 6. Hind wings dark olive-brown; cilia white between veins 5 and 6; a yellow-grey marginal streak at anal angle. Fore wings below reddish brown, markings bluish white partly edged with black; a streak at base of costa; a basal streak below subcostal; an antemedial fascia in cell, and one below it outset; a medial fascia in cell, with a white streak above subcostal, and a buff streak above costal vein; an outset medial fascia below cell, all of them narrower towards median, the two below cell suffusing on submedian; a fine black line on discocellular followed by small spots from costa to vein 4; two costal spots beyond, superposed, and small black spots on interspaces below; an interrupted subterminal white line preceded by a white point above vein 6, a large one below it, black spots below 5 and 4, and a still larger white spot between 3 and 2; a marginal silvery blue line; a fine terminal black line; cilia fuscous. Hind wings below reddish brown except on outer third; a white triangular spot on costa near base, and a quadrate medial spot; an antemedial white spot in cell, and transverse line across end of cell; two white spots below cell suffusing with a white streak below vein 1; a black line on discocellular, followed by a white fascia from veins 7 to 4, and from vein 2 to inner margin; black points in some of the reddish-brown spaces, which are also partly

black-edged; a postmedial reddish brown shade from costa to vein 4, followed by a macular black line, and then by a broad grey-brown shade crossed by a fine black line; postmedial space below vein 4 greyish brown to vein 1, then reddish brown on inner margin, followed by greyish brown shading from vein 4 to vein 1, and buff shading on inner margin, these shadings outwardly edged with black and followed by a silvery opalescent shade; outer margin dull dark brown outwardly edged with opalescent scaling, and containing small fuscous spots below vein 4 and vein 3; the tails and a terminal buff line from vein 4 to anal angle edged on either side with black; from vein 4 to apex the terminal line is reddish brown, preceded at apex by a short white line.

Expanse 24 mm.

*Hab.* Carillo.

Near *C. chrysus* Cr.

*CHARIS TURRIALBENSIS*, sp. n. (Pl. LIII. fig. 13.)

♂. Body above fuscous. Wings dark brown, with antemedial and postmedial fuscous shadings on interspaces. Fore wings: cilia at tornus orange-red. Hind wings: a black line on discocellular; a subterminal greyish buff shade from vein 6 to anal angle, crossed by a black macular line, preceded below vein 3 by a large brown spot, some reddish brown shading on inner margin at angle. Fore wings below orange-red; a pale buff triangular spot on costa near middle with its apex on median at vein 3, edged with silvery blue; similar metallic scaling on costa near base, and two inbent lines across cell; below cell and vein 2, medial, postmedial, and subterminal pale greyish shades, the intermediate red portions edged and suffused with black; a black line on discocellular, followed by metallic spots; below vein 5 a macular black line; outer pale greyish spots, followed above 5 and 6 by silvery streaks, preceded by silvery spots and some black edging, below vein 5 the greyish spots are inwardly edged with black, outwardly with metallic scaling and black edging; a marginal metallic line interrupted by veins. Hind wings below orange-red, divided by metallic antemedial, medial, and postmedial irregular lines, with some short black lines and spots in reddish portions; outer margin broadly pale greyish irrorated with brown; a marginal metallic line finely edged outwardly with black, and preceded by some black below veins 4 and 3; a terminal black line, also edging tails.

Expanse 21 mm.

*Hab.* Turrialba, 6000 feet.

Fam. LYCENIDÆ.

*THECLA HYPOCRITA*, sp. n. (Pl. LII. fig. 6.)

♂. Body dark brown mottled with bluish grey hairs and irrorations. Fore wings fuscous brown, except a pale blue space



occupying basal half of cell, space below to inner margin, and just above vein 2 to near subterminal space; a pale brown patch of coarse scales at end and beyond cell. Hind wings pale blue; outer margin fuscous brown; inner margin whitish, becoming fuscous towards anal angle; cilia brown tipped with grey. Fore wings below fuscous; costal margin broadly whitish, post-medially to vein 4; some brown mottling at base of costa; a brown medial fascia to median and end of cell enclosing a white line on discocellular; an outer and a subterminal oblique broad brown line to vein 5; outer margin narrowly white crossed by a fine marginal brown line. Hind wings below yellowish white, crossed by broad brown lines; a fuscous basal space, outangled on median; the inner margin broadly irrorated with fuscous and pale brown; medial and postmedial lines vertical, angled at vein 2 and inbent to inner margin; a subterminal brown shade suffusing with postmedial from veins 5 to 2, then continuing to anal angle; a broken marginal brown shade; anal angle slightly lobed, no tail.

Expanse 19 mm.

*Hab.* Tuis, Juan Vinas.

A specimen from Cordoba, Mexico, has the lines below partly greyish, but undoubtedly belongs to this species.

Near *T. dolyllas* Cr.

In British Museum.

*THECLA SUBFLORENS*, sp. n. (Pl. LII. fig. 9.)

♂. Antennæ black ringed with white. Body above fuscous, underneath white; some green scales on frons. Wings dark purple-slate colour. Fore wings: the costa, apex broadly, and outer margin fuscous brown. Hind wings: the margins narrowly fuscous brown. Wings below rich green. Fore wings paler tinged, except on costa and apex; the inner margin dark grey. Hind wings: a faint paler line on discocellular; a similar irregular outer line, black, outwardly edged with white from vein 2 to inner margin; a few red scales at anal angle, surmounted with black and white; a terminal black line at anal angle.

Expanse 20 mm.

*Hab.* Poas.

*THECLA LEOS*, sp. n. (Pl. LII. fig. 7.)

♂. Palpi black and white. Head, collar, and patagia black; white lines around eyes. Thorax and abdomen above metallic blue, underneath whitish. Wings brilliant dark blue. Fore wings: apex and outer margin black, narrowest at tornus; a large black patch filling the end of cell from before middle, followed beyond cell by a small slate-coloured spot. Hind wings: the termen narrowly black; the inner margin grey. Wings below clear bright brown. Fore wings: outer line fuscous brown, outwardly edged with white, faintly outbent, slightly lunular;

inner margin greyish; a faint dark marginal line at tornus. Hind wings: outer line fine, fuscous, outwardly edged with white, more broadly on costa, vertical from veins 8 to 6, appearing incurved on account of the broader white edging, slightly outset below 6 and below 5, inset below 4, outset below 3, inset and horizontal below 2, downbent on submedian, angled and upbent to inner margin; a fine subterminal black line from vein 3 to inner margin, and darker spots at apex; a marginal red spot with black point and terminal white line between 2 and 3; a black spot with white irrorations below vein 2; a black spot at anal angle surmounted by a reddish shade.

Expanse 24 mm.

*Hab.* Guapiles, La Florida.

I do not know any species with which I can compare this.

In British Museum.

*THECLA MELMA*, sp. n. (Pl. LII. fig. 4.)

♂. Palpi black, the base of joints white. Body black; some white on vertex, and white lines close to eyes. Wings deep blue. Fore wings: costa, apex, and outer margin black, the apical space reaching to near cell; a black line on discocellular. Hind wings: margins very narrowly black, slightly broader at apex. Wings below bright greyish bistre. Fore wings: an outer vertical fine fuscous line, outwardly edged with white from near costa to vein 2; a terminal fine brown line; cilia fuscous. Hind wings: a white line on discocellular; outer line black outwardly edged with white, outset on costa, almost vertical from veins 7 to 4, then inset and downbent to vein 2, forming the usual **W** to inner margin; subterminal lunules indicated by greyish shading from vein 7 to vein 2, followed between 2 and 3 by a large red space, outwardly broken by a triangular black space; some reddish scales above vein 3; below vein 2, marginal white irrorations; a terminal white line from vein 5 to submedian; anal lobe black inwardly edged with white.

Expanse 27 mm.

*Hab.* Guapiles; also Bugaba, Panama.

*THECLA GUAPILA*, sp. n. (Pl. LII. fig. 1.)

♂. Thorax and base of abdomen metallic blue, abdomen otherwise fuscous above, yellowish white below. Head brown, with white lines at eyes. Wings silky blue. Fore wings: costal margin, apex to near glandular spot, and outer margin, narrowly at tornus, black; a small black spot at end of cell followed by an oval brownish glandular spot. Hind wings: apex narrowly, and cilia black. Wings below dark brownish slate-colour. Fore wings: inner margin greyish; a fine outer fuscous line, almost vertical from below costa to vein 2, outwardly faintly pale-edged; faint traces of a dark subterminal line. Hind wings: outer line interrupted, dark brown, outwardly edged with white, inbent on

costa, vertical from veins 7 to 2, but inset between 3 and 4, angled below vein 2, and indented to inner margin; subterminal darker spots, edged with whitish irrorations, except at apex, inset between veins 2 and 3, followed by a red marginal spot, containing a small black spot outwardly; below vein 2 only a marginal brown spot irrorated with white; below submedian a line inwardly edged with white and parallel with outer line; a terminal white line between veins 2 and 3; anal lobe black.

Expanse 28 mm.

*Hab.* Guapiles.

In British Museum.

*THECLA AMPHRADE*, sp. n. (Pl. LII. fig. 10.)

♀. Wings fuscous brown, the hind wings, and inner area of fore wings below cell glossed with slate-blue; cilia light brown. Hind wings: the terminal black line inwardly edged with white near anal angle; a small red-brown spot at anal angle; tails black tipped with white. Wings below light brown, the post-medial line dark brown outwardly edged with black and then white, very indistinctly on fore wing. Fore wings: the line vertical from costa to vein 2; an indistinct paler subterminal shade, crossed by a faint dark line; a terminal fine dark line. Hind wings: the line vertical to vein 4, constricted and slightly oblique to vein 2, upcurved and outangled on submedian; a subterminal paler shade as on fore wing, the faint line crossing it more distinct followed on inner margin, between veins 2 and 3 and just above 3, by reddish shades; a black marginal spot between veins 2 and 3 and at anal angle; a black spot irrorated with white below vein 2; the terminal dark line inwardly edged with white.

Expanse 23-25 mm.

*Hab.* Guapiles.

Near *T. politus* H. Druce.

In British Museum.

#### Subfam. PIERINÆ.

*ARCHONIAS INTERMEDIA*, sp. n. (Pl. LII. fig. 8.)

♂. Palpi yellow, somewhat fuscous at base. Head and thorax black; three whitish points on vertex. Abdomen brown; sub-lateral yellow line. Fore wings black, markings yellow-white; an oblique spot at end of cell, medially constricted; two diffuse spots beyond cell; elongated postmedial spots above and below vein 3, and geminate streaks below 2, all followed by marginal spots, small at tornus, elongated towards costa; a yellow and reddish streak along inner margin, not reaching base or tornus. Hind wings bright brownish red, the costal and outer margins broadly black, the inner margin finely so; the veins black; cell edged with black above and below; marginal small white spots. Underneath duller, the hind wings browner, with a brown up-

curved streak on basal half of costa; the subcostal and median broadly shaded with black; the marginal white spots larger.

♀. The markings on fore wings reduced, except the marginal spots; the hind wings reddish brown, the costa with only a black shade medially; the marginal spots larger, yellow, irrorated with reddish. Underneath similar to the male.

Expanse, ♂ 60 mm., ♀ 65 mm.

*Hab.* Carillo.

The fore wings are like *A. dimorphites* Btl., the hind wings like *A. nigrescens* G. & S. All these forms will no doubt be found to gradually intergrade. The males are difficult to capture, flying very high in a circle, and rarely settling.

In British Museum.

*PIERIS LIMONA*, sp. n. (Pl. LII. fig. 5.)

♂. Antennæ black tipped with white. Head and thorax fuscous, the latter clothed behind with white hairs. Palpi white, the third joint streaked with black. Abdomen fuscous grey above, whitish below. Wings white, the veins broadly edged with chalky white. Fore wings: a fuscous grey streak on basal third of costa; a small black spot on discocellular; apex narrowly black; marginal fuscous shades, not reaching tornus. Hind wings: cilia black. Fore wings below: a large black spot on discocellular; apex greyish. Hind wings below yellowish white, the veins dark.

♀. Fore wings above with a large black spot on discocellular, and a fuscous streak in cell at subcostal reaching it; the apex and termen more broadly black, its inner edge somewhat lunular; underneath the black margin replaced by a pale lilacine grey shade. Hind wings below lilacine white, the veins brown; a postmedial brownish shade just beyond cell across veins 3 and 4.

Expanse, ♂ 75 mm., ♀ 78 mm.

*Hab.* Limon.

Near *P. diana* Feld.

In British Museum.

*ACMEPTERON POASINA*, sp. n. (Pl. LII. fig. 3.)

♂. Antennæ black. Palpi grey. Head and collar dark brown. Thorax and abdomen fuscous irrorated with white. Fore wings black; median, fold, submedian, and vein 2 all basally streaked with white; spots lilacine white; a medial streak on costa, spot beyond cell, an outer spot above vein 3, and one on costa, also a small subterminal spot above 6; sometimes traces of spots on either side of upper discocellular; cilia greyish brown. Hind wings iridescent silky brown with a large medial dull brown spot; from cell behind to inner margin and termen at vein 5 black, crossed by a grey fascia; cilia yellow. Wings below as in *A. cinerascens* Salv., but the markings all more intense, the anal angle and inner margin bright yellow crossed by purple-brown stræ.

♀. Wings black, the markings white. Fore wings: an oblique fascia from middle of costa consisting of coalescing spots; three oblique spots from costa before apex; the outer half of inner margin with a white streak. Hind wings: a large white space occupying the greater portion of the wing, outangled on vein 5, its hind edge straight; the base of cell and a streak below it black. Fore wings below: a white space on basal half from within cell to inner margin; costa basally lilacine; the medial fascia as above but with a yellow streak on costa; apex lilacine white, shaded with yellow on costa; termen finely yellow, preceded by light brown and greyish white shading. Hind wings below white: the base, outer half from inner margin to vein 4, and terminally between 4 and 5 lilacine white irrorated with brown; the shade in cell extending somewhat, and upbent to costa; subterminal brown irrorations from costa to vein 6; inner margin narrowly bright yellow, termen finely similar preceded by a narrow interrupted brown shade.

Expanse, ♂ 60 mm., ♀ 67 mm.

The male can be distinguished from *A. cinerascens* Salv. by the narrow grey fascia on hind wings above. The female differs in the broader black margin, the lilacine shading, and brown irrorations on hind wings. A *cinerascens* female has the hind wings below bluish white with faint traces of darker shadings. If the two forms occurred in different localities I should not separate them specifically, but they fly together and no intergrades were found.

In British Museum.

ENANTIA LUA COSTARICENSIS, subsp. n. (Pl. LII. fig. 2.)

♂. Like *E. lua* Hew., but the inner edge of black margin on hind wings near apex is straight, not dentate; underneath the spots are larger and more confluent. The wings are also broader.

Expanse 62 mm.

Hab. Cachi.

#### FAM. HESPERIIDÆ.

TELEMIADES MNEMON, sp. n. (Pl. LIV. fig. 1.)

♂. Palpi white below, black above with yellow scales at tip of second joint. Head and collar black mottled with yellow. Thorax and abdomen brown. Fore wings dark brown, the base to near middle thickly irrorated with yellow-brown hairy scales; similar scaling subterminally, expanding at tornus, also a few similar scales beyond cell; medial space below cell tinged with blue-black; spots semihyaline yellowish; a large spot in end of cell, its outer edge incurved; a narrow vertical postmedial spot between veins 2 and 3, and a small spot above 3, slightly outset; three small outer spots below costa, and two subterminal between veins 4 and 6. Hind wings with only the costal margin, a postmedial macular shade, and terminal spots fuscous brown, otherwise overlaid with yellow-brown hairy scales. Fore wings below

dull fuscous brown; the inner margin tinged with grey; some yellow scaling at base, below costa, and in cell. Hind wings below dull brownish yellow; the outer margin broadly dark brown; some brownish-yellow scaling subterminally from vein 3 to inner margin.

Expanse 28 mm.

*Hab.* Zent district.

*NASCUS PHINTIAS*, sp. n.

♂. Palpi white tipped with black above. Head and collar fuscous mottled with olive-brown; white points laterally on head. Thorax and abdomen shaded with orange-brown. Fore wings fuscous brown, the base and inner margin shaded with orange-brown; spots semihyaline whitish; a spot at end of cell, outwardly produced in front; a large postmedial spot between veins 3 and 4, and a smaller one below 2; an outset large spot between veins 3 and 4, and a point between 4 and 5; a curved outer series of spots between veins 6 and 10. Hind wings orange-brown, the costal margin broadly fuscous, the termen narrowly so; a fuscous line on discocellular; a broader postmedial line not reaching inner space. Wings below brown-black. Fore wings: the base shaded with yellow-white; short whitish streaks above cell-spot. Hind wings: the basal half and inner margin for two-thirds pale yellow; a thick black line on discocellular.

Expanse 55 mm.

*Hab.* Guapiles.

The female of this species is figured in the Appendix to the 'Biologia' as a variety of *N. phocus* Cr., but the discovery of the male proves it to be a distinct species.

*CYCLOSEMIA SUBCERULEA*, sp. n. (Pl. LIV. fig. 14.)

Body fuscous brown. Wings dark greyish brown, the markings fuscous brown; a postmedial and marginal broad line, somewhat macular, also a similar medial line on hind wings. Fore wings: the costa and termen broadly shot with green, the veins more vividly so towards apex, but only noticeable in a certain light; a large black spot in cell at end, faintly edged with paler brown, and containing two bluish-white points. Fore wings below dark brown shot with green; the inner margin shaded with grey; a fuscous shade in end of cell; a postmedial fuscous shade. Hind wings below bright blue; the costa, apex narrowly, and cilia dark brown.

Expanse 31 mm.

*Hab.* Sixola, Guapiles.

In British Museum.

*ECHELATUS LUCINA*, sp. n. (Pl. LIV. fig. 8.)

Body fuscous brown, the vertex and collar glossed with green. Wings fuscous brown. Fore wings glossed with purple; an ante-

medial and a postmedial fuscous shade, the latter slightly out-curved below costa, vertical below vein 4. Hind wings with fainter purple gloss, except a streak below cell from base to termen; a fuscous shade at end of cell, and a similar postmedial shade. Wings below paler brown, the lines as above, dark brown; the antemedial on fore wings replaced by a dark brown shade from near base to middle, except on inner margin, which is whitish grey at base.

Expanse 37 mm.

*Hab.* Guapiles.

*ATE CANACE*, sp. n. (Pl. LIV. fig. 17.)

♂. Body and wings fuscous brown. Fore wings: a semi-hyaline point medially between vein 11 and costal vein; a similar outer point between veins 8 and 9, and one below 8 slightly inset. Hind wings: outer margin broadly blue from vein 6 to inner margin; cilia fuscous brown. Fore wings below duller. Hind wings below blue; inner margin whitish blue; costal margin and apex to vein 6 dull fuscous brown; a similar downbent streak from vein 2 to anal angle.

Expanse 23 mm.

*Hab.* Carillo.

*BOLLA SODALIS*, sp. n. (Pl. LIV. fig. 12.)

♀. Palpi brown mottled with buff and white. Body fuscous brown. Wings brown slightly irrorated with lighter brown and buff. Fore wings: a fuscous shade on discocellular followed by a faint paler brown shade; three outer white hyaline spots below costa, straight and outbent; three similar postmedial vertical fine streaks between submedian fold and vein 4; a faint subterminal paler brown shade cut by darker veins. Hind wings: a faint subterminal paler brown shade narrower than on fore wings. Wings below duller brown; the subterminal shade on fore wings narrow; hind wings irrorated with buff-brown; a small pale brown spot in cell, a streak on discocellular, some small post-medial spots near inner margin, and the subterminal spots all very indistinct.

Expanse 29 mm.

*Hab.* El Alto.

Nearest *B. cylindus* G. & S.; smaller, the spots also smaller; the outer spots in a straight line and oblique.

*BOLLA MACHUCA*, sp. n. (Pl. LIV. fig. 4.)

♂. Body above fuscous brown; some greyish white hairs in front of antennæ; some yellowish white hairs on abdomen. Throat white; fore femora grey. Abdomen below greyish brown. Fore wings fuscous brown; outer margin faintly paler, forming a subterminal line with darker marginal spots on interspaces; three white points outwardly between veins 6 and 9.

Hind wings dark brown; large postmedial and marginal fuscous brown shades, all indistinct and confused. Fore wings below dark greyish brown; a broad darker postmedial shade; the costa tinged with iridescent green; the white points as above. Hind wings below dark brown; some white irrorations on basal half, and more thickly along inner margin; traces of a darker postmedial shade, and small marginal spots.

Expanse 26 mm.

*Hab.* San Mateo.

In British Museum.

*BUTLERIA LETHÆA*, sp. n. (Pl. LIV. fig. 15.)

♂. Palpi black mottled with yellowish hairs. Body above black; some orange hairs on abdomen; abdomen below yellow. Fore wings fuscous brown; a large orange-yellow spot just beyond middle between veins 2 and 4, extending into end of cell, and slightly below vein 2; a small oblique similar spot outwardly below costa; cilia dark brown. Hind wings black; cilia and a large spot occupying middle of wing orange-yellow. Fore wings below deep yellow: cell to near end black, extending at base below cell; a broad black fascia beyond cell, not reaching costa, outbent above vein 4, and downturned to inner margin at tornus. Hind wings below yellow; some black scaling at base of inner margin.

Expanse 20 mm.

*Hab.* Poas.

Near *B. lalage* Godm.

In British Museum.

*BUTLERIA LYSIS*, sp. n. (Pl. LIV. fig. 2.)

♂. Body above black; abdomen below yellow. Wings dark brown, spots yellow. Fore wings: a spot between veins 2 and 3, just beyond middle, surmounted by a triangular spot in cell; a point between veins 3 and 4 postmedially, and a short oblique line outwardly below costa. Hind wings: a large spot in middle of wing from within cell. Fore wings below fuscous; costal margin yellow-brown, the extreme edge black; termen finely yellow expanding at apex; the yellow discal spot extending below vein 2 and expanding along submedian. Hind wings below whitish yellow, the veins brown except the discocellular and base of vein 5, the brown on veins 2 and 4 suffusing somewhat towards cell; cilia brown.

Expanse 23 mm.

*Hab.* Turrialba.

Near *B. faula* Godm.

*LERODEA ? RUPILIUS*, sp. n. (Pl. LIV. fig. 10.)

♀. Palpi pale brown tipped with white. Body above and wings dark brown; body below whitish grey. Wings: spots



semihyaline white; outer half of cilia greyish white with small dark brown spots at veins. Fore wings: a large spot at end of cell, and one postmedially between veins 2 and 3; a smaller out-set spot between 3 and 4; three outer small spots obliquely between veins 6 and 9; a more opaque spot above submedian beyond middle. Hind wings: a postmedial spot below vein 6, crossed by vein 5. Fore wings below similar, the costa irrorated with yellowish and white, the apex and termen to vein 2 with white; the spot above submedian replaced by a large white shade. Hind wings below thickly irrorated with greyish white; small whitish spots antemedially and postmedially below costal vein; a similar spot at end of cell; a small postmedial spot between veins 2 and 3, and a linear spot below vein 2; the spot below vein 6 as above; the postmedial spots connected by a fine brown shade, and a similar faint shade below end of cell.

Expanse 36 mm.

*Hab.* Guapiles.

The only species I know approaching this is one in the Godman Collection labelled "*phyllas* Mab." Without a male the position is uncertain.

#### STYRIODES, gen. nov.

♂. Antennæ two-thirds as long as costa. Fore wings: costal margin slightly sinuous; apex acute; termen rounded below apex; vein 2 from middle of cell; 3 near lower angle; 4 and 5 from lower angle, the latter upcurved at base; 6 to 9 evenly apart; 10 and 11 wider spaced; a downcurved brand below median from vein 3 to below vein 2; a small medial brand above submedian. Hind wings: anal angle slightly lobed; vein 2 beyond middle of cell; 3 and 4 from lower angle apart; 6 and 7 from upper angle.

Type of genus, *Styriodes lyco* Schaus.

#### STYRIODES LYCO, sp. n. (Pl. LIV. fig. 19.)

♂. Body and wings above fuscous brown. Fore wings: brands black; cilia tipped with yellow-ochre, wider at tornus. Hind wings: cilia tipped with yellow-ochre, except at anal angle. Wings below dark reddish brown, the inner margin of fore wings dull dark brown; a fuscous brown shade in cell behind and below it.

Expanse 28 mm.

*Hab.* Poas.

#### RHINTON LUCTATIUS, sp. n. (Pl. LIV. fig. 9.)

♂. Body above black, the head shaded with dark metallic green; abdomen below with two yellowish white lines. Wings fuscous brown. Fore wings: a very small greyish white postmedial spot between veins 2 and 3, and one between 3 and 4 outset. Wings below not quite so dark. Fore wings: the two spots whiter, better defined; a postmedial greyish brown shade

below vein 2. Hind wings: postmedial buff points between veins 2 and 4.

Expanse 44 mm.

*Hab.* Guapiles, also Santa Rosa, Mexico.

In British Museum.

*COBALUS NIGRANS*, sp. n. (Pl. LIV. fig. 5.)

♂. Palpi and thorax fuscous grey mottled with pale yellow; abdomen below with two fine whitish lines. Wings black-brown. Wings below duller. Fore wings: a faint greyish white postmedial line between veins 2 and 3, and a small outset spot above 3; tornus shaded with fuscous grey. Hind wings: an orange point in cell at end; similar outer points between veins 3 and 4, and just below 6.

Expanse 30 mm.

*Hab.* Guapiles.

*COBALUS LAUREOLUS*, sp. n. (Pl. LIV. fig. 3.)

♂. Body fuscous clothed with dark brown hairs; the palpi mottled with some whitish yellow hairs; abdomen below greyish brown. Fore wings: veins medially tinged with fuscous. Hind wings: basal half rather darker shaded. Wings below paler brown. Fore wings: basal third except costa shaded with fuscous; a triangular shade on costa near apex preceded by faint greyish points between veins 6 and 9; tornus faintly paler shaded. Hind wings: base, a postmedial fascia, and large marginal spots from apex to vein 2 darker brown; a terminal darker brown line.

Expanse 35 mm.

*Hab.* Guapiles.

*COBALUS LATERANUS*, sp. n. (Pl. LIII. fig. 3.)

♂. Palpi fuscous inwardly shaded with white. Body and wings fuscous brown. Fore wings: spots semihyaline, white; a large irregular spot at end of cell; a large postmedial spot between veins 2 and 3, and a small outset spot above 3; three small outer spots below costa, outbent, the largest between veins 6 and 7; a small postmedial white spot above submedian. Fore wings below fuscous, the costa, apex, and termen shaded with olive-brown; the spot above submedian larger. Hind wings below dark olive-brown; a white spot in end of cell; a white point subterminally between veins 3 and 4.

Expanse 32 mm.

*Hab.* San Mateo.

The fore wings above are like *C. gabina* Godm.

*COBALUS PINDAR*, sp. n. (Pl. LIV. fig. 18.)

♂. Palpi olive-yellow irrorated with brown. Body and wings above dark brown; abdomen below yellowish bistre. Fore

wings: spots semihyaline whitish brown; a large spot between veins 2 and 3, its outer edge incurved; a small spot between 3 and 4; three small spots between veins 6 to 9 in a straight out-bent line from costa; cilia tipped with bistre grey. Hind wings: a yellow postmedial hyaline point between veins 3 and 4. Fore wings below fuscous brown, the costal margin broadly, and cell shaded with yellow-brown, the spots as above; a whitish post-medial shade above submedian. Hind wings below brown; a small faint fuscous shade at discocellular, and similar spots post-medially from veins 2 to 7, the one between 3 and 4 showing the semihyaline point.

Expanse 29 mm.

*Hab.* Port Limon, Juan Vinas.

In British Museum.

*COBALOPSIS LATONIA*, sp. n. (Pl. LIV. fig. 16.)

♂. Body fuscous brown; palpi above whitish grey; abdomen below pale buff. Wings dark brown. Fore wings: a fine short whitish inbent streak below discocellular; a small white postmedial spot between veins 3 and 4, also above and below vein 7. Hind wings: the veins fuscous. Fore wings below fuscous in cell and postmedially below vein 3, the inner margin irrorated with greyish; costa, apical space, and termen yellowish brown. Hind wings below yellowish brown; a fuscous shade near inner margin expanding at anal angle; five bluish white post-medial spots from veins 2 to 7.

Expanse 33 mm.

*Hab.* Juan Vinas, Cachi.

In British Museum.

*GENUS NAUSIPHANES*, sp. n. (Pl. LIV. fig. 6.)

♂. Palpi mottled whitish grey and dark brown. Body fuscous brown; abdomen below whitish grey; legs yellow-brown. Wings dark brown. Fore wings: the brand fine, black, inbent from vein 3, and downcurved to submedian; some yellowish scaling on costa; cilia tipped with grey. Hind wings: cilia yellow-grey. Fore wings below fuscous at base, in, and below cell; costa yellowish brown; terminal half dull brown. Hind wings dull brown; a broad medial whitish shade, widest on costa and not reaching inner margin which is simply irrorated with whitish grey.

Expanse 25 mm.

*Hab.* Poas.

In British Museum.

*MEGISTIAS XANTHO*, sp. n. (Pl. LIV. fig. 13.)

♂. Body fuscous mottled with brown hairs. Wings fuscous brown. Fore wings: a yellow-brown streak on costa from base to just beyond middle; a similar streak above submedian medially extending towards base; a few similar scales outwardly beyond

cell, outbent along vein 6, vertical to below 5, inbent, expanding, forming a spot between 4 and 3, and a larger spot between 3 and 2; cilia light brown spotted with black. Hind wings: some yellow-brown hairs at base and on inner margin; a broad similar postmedial shade not reaching margins; the spots on cilia narrow, barely traceable. Fore wings below fuscous; veins on costa, and terminally, also a streak in cell, yellowish; a postmedial yellowish spot between veins 3 and 4, a vertical outer streak below costa, and streak subterminally from veins 6 to 4; a terminal yellowish line; base of cilia and spots black. Hind wings below greyish tinged with lilacine, the veins yellowish; an outcurved dark brown medial fascia, and large terminal spots, not reaching inner margin.

Expanse 20 mm.

*Hab.* Juan Vinas.

In British Museum.

*VORATES COTISO*, sp. n. (Pl. LIII. fig. 6.)

♂. Body above and wings dark brown; throat whitish; thorax below greyish; abdomen below yellowish white. Fore wings: costal margin to beyond middle bright olive-brown; a similar streak above and below submedian to middle, followed above submedian by a small yellow spot; a yellow streak below median from veins 2 to 3; a small spot between 3 and 4; an outer yellow point between veins 6 and 7. Hind wings shaded with bright brown, and olive-brown hairs. Fore wings below fuscous brown; yellow marking between veins 2 and 4 as above; costa and veins terminally yellow, the streaks longest at apex. Hind wings below dull dark brown, the veins all yellow; a streak through cell, and a broad yellow streak below cell and vein 2.

Expanse 24 mm.

*Hab.* San Mateo.

*MOLO NEBROPHONE*, sp. n. (Pl. LIV. fig. 7.)

♂. Palpi orange-brown tipped with black. Body fuscous partly clothed with golden-brown hairs; abdomen below yellowish with a black ventral line. Fore wings black, except base of costal margin to near middle, cell, inner margin to beyond middle, postmedial spots from submedian to vein 4, a small outer spot above 4, and spots above and below vein 7, which are orange-brown; a slight fuscous streak in cell. Hind wings orange-brown; costal margin broadly black with a medial inbent projection; inner margin broadly black; a broad black streak below cell to middle of wing; a fuscous shade on termen towards anal angle. Fore wings below deep yellow; some black on base of cell; a broad black shade below cell, upbent on discocellular; termen black from vein 2 to inner margin; apex shaded with reddish, the outer spots at vein 7 larger. Hind wings below yellow on basal half; the inner margin broadly black

irrorated with yellow-brown; outer half reddish with oblong outer yellow spots from vein 6 to below vein 2; subterminal fuscous shading between veins 2 and 4; a darker streak just beyond cell between 4 and 6.

♀ fuscous brown; a small yellow spot at upper angle of cell; traces of some postmedial yellowish spots. Fore wings below fuscous; costal margin yellowish; apex tinged with dull reddish; a yellow spot at end of cell; a large postmedial yellow spot below vein 2, and smaller spots above 2 and 3; small yellow outer spots above and below vein 7. Hind wings below as in male, the terminal space duller red, limited by a yellow streak before the fuscous inner space.

Expanse, ♂ 27 mm., ♀ 33 mm.

*Hab.* Carillo.

The female from the Bejuco river, Panama.

Near *M. hercea* Hew.

MOLO? APELLA, sp. n. (Pl. LIII. figs. 4, 5.)

♂. Palpi, head, collar, and patagia orange-brown. Thorax and abdomen fuscous, the latter with orange-brown hairs laterally; underneath yellowish. Wings black, the cilia and markings orange-brown. Fore wings: the costal margin broadly orange-brown, entering cell, narrowing towards black apical space; a fascia from vein 8 narrow and outangled between veins 5 and 6, then broader and expanding to middle of inner margin, cut by black veins. Hind wings: base and inner margin clothed with orange-brown hairs; a broad postmedial fascia, not reaching apex or inner margin. Wings below brownish yellow; some terminal black points. Fore wings: the outer margin broadly darker with subterminal black shadings from vein 3 to inner margin; a black space on basal third below cell; a fine black line on discocellular. Hind wings: antemedial, postmedial, and terminal darker shadings on interspaces.

♀. Wings above tinged with brown, the fascia much reduced, more macular, yellowish; the costa of fore wings with some yellowish irrorations. Wings below dark olive-brown, the veins paler; the postmedial fascia on fore wings broad, as in male, but yellower. Hind wings with postmedial dull yellowish spots on interspaces.

Expanse, ♂ 37 mm., ♀ 45 mm.

*Hab.* Carillo.

The male above is very much like *M. ? humeralis* Mab., but differs considerably on the underside of hind wings.

In British Museum.

CARYSTUS SUBRUFESCENS, sp. n. (Pl. LIV. fig. 11.)

♀. Palpi whitish buff. Head light brown. Palpi shaded with dull reddish brown. Abdomen fuscous brown, the hairs at base dull greyish green. Wings fuscous brown. Fore wings: costal

margin at base shaded with reddish; spots semihyaline whitish yellow; a streak in end of cell above median, and a spot below it to vein 2, its outer edge incurved; an elongated postmedial spot above vein 4, and a smaller spot below it; small outer spots between veins 6 and 8; a small yellowish spot above submedian just beyond middle; cilia yellowish at tornus. Hind wings: cilia tipped with pale yellow. Fore wings below black; the costal margin, apical space beyond cell, and termen to vein 2 brownish red; a yellowish white shade medially above submedian. Hind wings below brownish red; veins finely pale yellow; a fuscous shade from base before fold, expanding at anal angle.

Expanse 36 mm.

*Hab.* Guapiles.

Near *C. commodus* Plötz, distinguished by the pale veins on hind wings below.

#### EPINOSIS, gen. nov.

♂. Palpi upturned, hairy. Antennæ more than half the length of fore wing, thickened towards end which is curved and pointed. Wings broad. Fore wings: outer margin evenly curved; vein 2 from middle of cell; 3 close to lower angle; 4 from lower angle; 5 from below middle of discocellular, which is slightly oblique; 6, 7, 8 close together; a narrow band below median from vein 3 to 2. Hind wings: veins 3 and 4 from lower angle slightly apart; 6 and 7 from upper angle.

Type of genus, *Pamphila angularis* Möschl. = *Hesperia parvipuncta* Möschl. *vide* Godman. (Pl. LIII. fig. 1.)

A common species in Costa Rica not mentioned in the 'Biologia', and agreeing perfectly with other specimens from the Guianas.

#### FALGA? HERMIONE, sp. n. (Pl. LIV. fig. 20.)

♂. Palpi black, the second joint with a lateral white shade. Body above fuscous with orange-brown hairs; abdomen below yellowish white with a fine interrupted medial and outer black line. Fore wings black; base of costa shaded with brown; subcostal broadly orange-brown, not reaching apex, beyond cell with short upbent lines; a broad postmedial orange-brown shade inbent from vein 4 to submedian, its edge uneven, and joined by a similar streak below cell; cilia orange-brown partly spotted with black, entirely black at apex. Hind wings and cilia orange-brown, the margins black; a black streak from base near inner margin. Wings below orange-brown. Fore wings: a black streak through cell, and on interspaces above and below vein 5; tornus black; subterminal black spots on other interspaces, and streaks on costa towards apex. Hind wings: a terminal black line; a streak below cell and vein 2, and one at apex; subterminal black spots above and below vein 3.

The female has the orange-brown on fore wings more restricted.

Expanse 26 mm.

*Hab.* Carillo.

In British Museum.

# EXPLANATION OF THE PLATES.

## PLATE L.

- Fig. 1. *Napeogenes hemisticta*.  
2. *Ithomia bolivari*.  
3. *Pteronymia fumida*.  
4. *Euptychia agnata*.  
5. *Catargynnis dryadina*.

- Fig. 6. *Euptychia drymo*.  
7. *Eresia sticta*.  
8. „ *cæla*, ♂.  
9. *Phyciodes phlegias*, ♀.

## PLATE LI.

- Fig. 1. *Eurygona leucon*, ♂.  
2. *Eupetioleta poasina*.  
3. *Eurygona leucon*, ♀.  
4. *Eubagis hecuba*, ♂.  
5. „ „ ♀.

- Fig. 6. *Victorina steneles*, ab. *stygiانا*.  
7. *Eurygona matuta*.  
8. „ *mystica*.  
9. *Phyciodes dora*.  
10. *Perisama barnesi*.

## PLATE LII.

- Fig. 1. *Thecla guapila*.  
2. *Enantia lua costaricensis*.  
3. *Acmepteron poasina*, ♀.  
4. *Thecla melma*.  
5. *Pieris limona*, ♀.

- Fig. 6. *Thecla hypocrita*.  
7. „ *leos*.  
8. *Archonias intermedia*, ♂.  
9. *Thecla subflorens*.  
10. „ *amphrade*.

## PLATE LIII.

- Fig. 1. *Epinosis angularis*.  
2. *Corvachia leucoplaga*.  
3. *Cobalus lateranus*.  
4. *Moto ? apella*, ♂.  
5. „ „ ♀.  
6. *Varates cotiso*.  
7. *Heliconius galanthus*, ab. *sub-rufescens*.

- Fig. 8. *Eurygona leucophryna*.  
9. *Hermathena oweni*.  
10. *Phyciodes nireonotis*, ♀.  
11. *Charis subtessellata*.  
12. *Mesosemia albipuncta*.  
13. *Charis turrialbensis*.

## PLATE LIV.

- Fig. 1. *Telemiades mnemon*.  
2. *Butleria lysis*.  
3. *Cobalus laureolus*.  
4. *Bolla machuca*.  
5. *Cobalus nigrans*.  
6. *Enus nausiphanes*.  
7. *Moto nebrophone*.  
8. *Echelatus lucina*.  
9. *Rhinthon luctatus*.  
10. *Lerodea ? rupilius*.

- Fig. 11. *Carystus subrufescens*.  
12. *Bolla sodalis*.  
13. *Megistias xantho*.  
14. *Cyclosemia subcærulea*.  
15. *Butleria lethæa*.  
16. *Cobalopsis latonia*.  
17. *Ate canace*.  
18. *Cobalus pindar*.  
19. *Styriodes lyco*.  
20. *Falga ? hermione*.

27. A Collection of Fishes made by Professor Francisco Fuentes at Easter Island. By C. TATE REGAN, M.A., F.Z.S.

[Received March 3, 1913: Read April 8, 1913.]

(Plates LV.-LX.\*)

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Easter Island lies in  $27^{\circ} 6' S.$  and  $109^{\circ} 17' W.$ ; it is very isolated, distant about 2500 miles from the coast of Chile and nearly 1000 miles from Ducie, the nearest island of the Paumotu Archipelago. A small collection of fishes made at Easter Island in April, 1911, by Professor Fuentes, is of considerable interest. It includes examples of eleven species: seven belong to genera or species of the tropical Pacific, three are new and are related to species known from Norfolk Island or from New South Wales, and one belongs to a new genus whose affinities are with *Tephreops* of New South Wales and the southern coasts of Australia. No Chilean species are represented, and it is of interest to note that in the case of Chilean genera, *Acanthistius* and *Labrichthys*, relationship is with the Norfolk Island species and not with the Chilean ones.

SERRANIDÆ.

1. ACANTHISTIUS FUSCUS. (Pl. LV.)

*Acanthistius cinctus* (non Günth.) Kendall & Radcliffe, Mem. Mus. Comp. Zool. xxxv. 1912, p. 107.

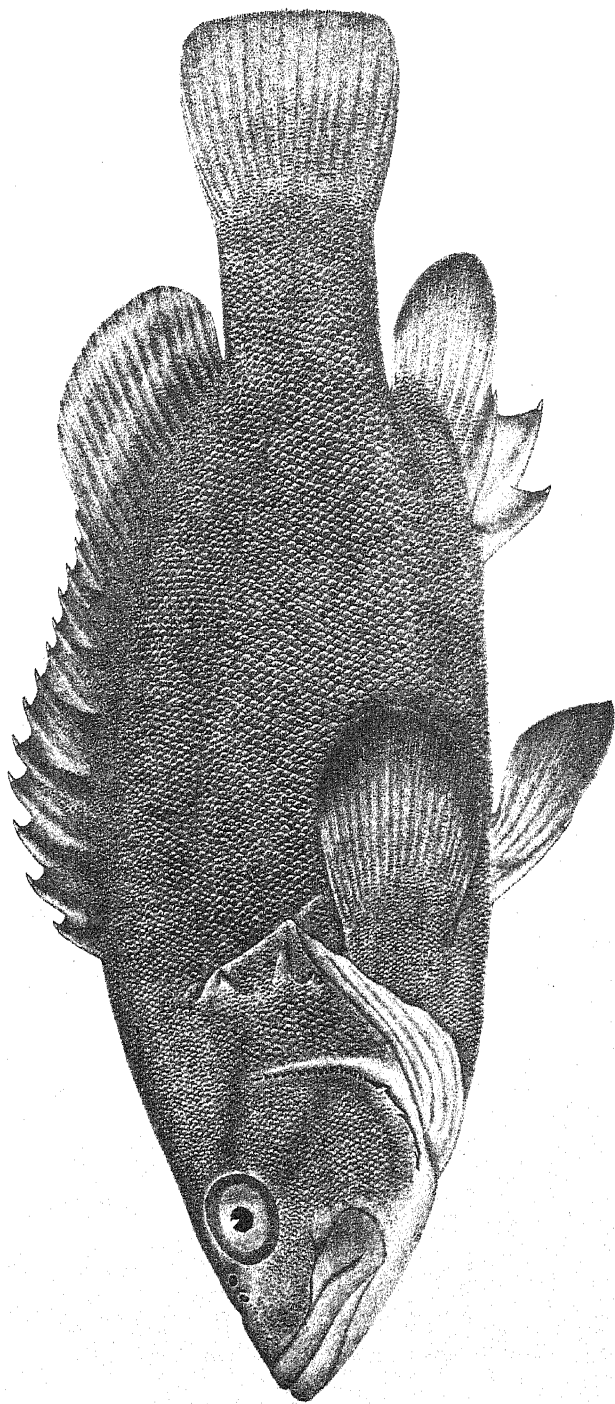
"Capuco."

Depth of body  $2\frac{3}{4}$  in the length, length of head  $2\frac{3}{4}$ . Snout  $1\frac{2}{3}$  as long as diameter of eye, which is  $5\frac{1}{3}$  in the length of head; interorbital width 7. Lower jaw a little projecting; maxillary extending to below middle of eye, its width distally nearly  $\frac{3}{4}$  diameter of eye; occiput, interorbital region, cheeks, and opercles covered with ciliated scales; rest of head naked, or with minute imbedded scales; 9 or 10 gill-rakers (and some rudiments) on lower part of anterior arch. Scales strongly ciliated, 105 in a longitudinal series above the lateral line, 55 in the lateral line, 17 from base of spinous dorsal to lateral line. Dorsal XIII 15; fourth to sixth spines longest,  $\frac{2}{3}$  length of head,  $\frac{3}{4}$  longest soft rays. Anal III 8; second spine longest and strongest,  $\frac{1}{3}$  length

\* For explanation of the Plates see p. 373.



PZ.S.1913.PLLV.

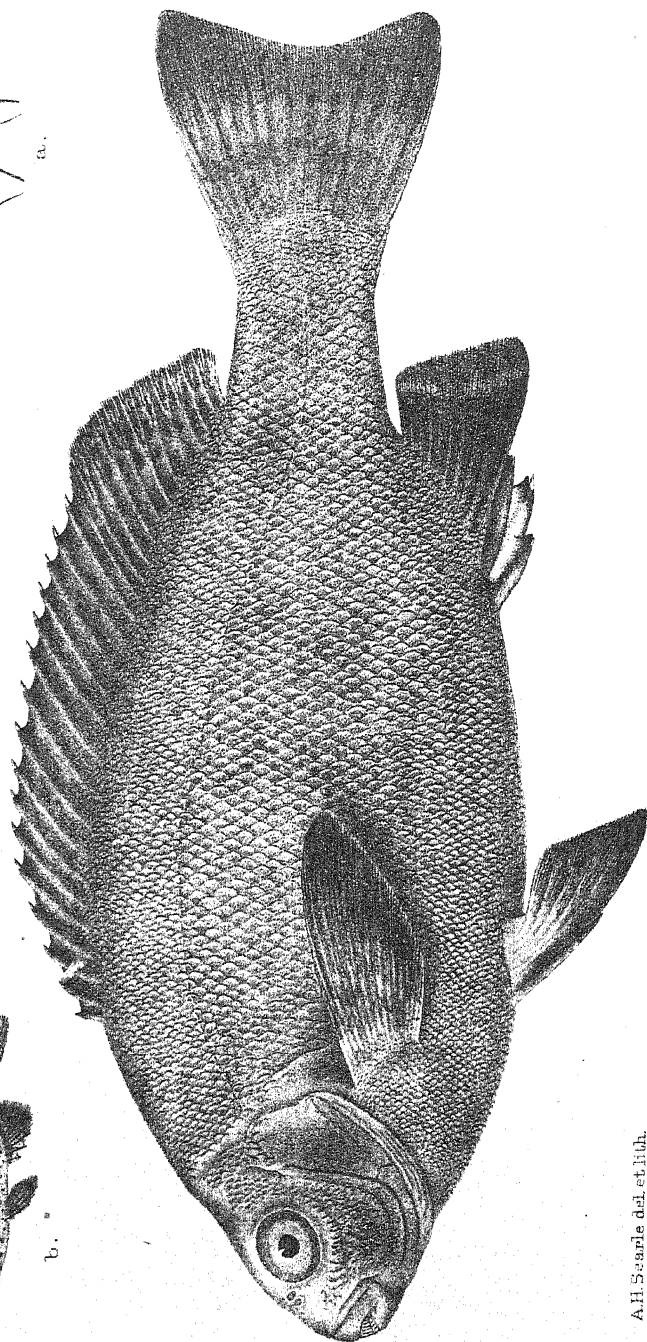


A.H.Searle del. et lith.

ACANTHISTIUS FUSCUS.

Hutch imp.



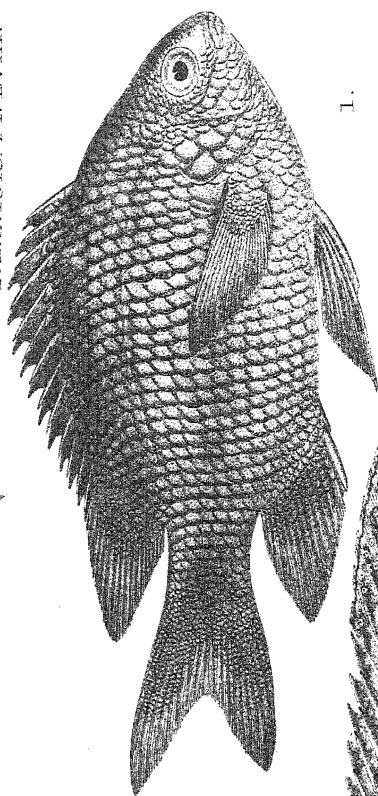


A. H. Searle del. et lith.

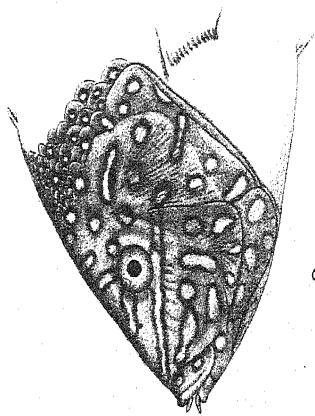
GIRELLOPS NEBULOSUS.

Hath imp.

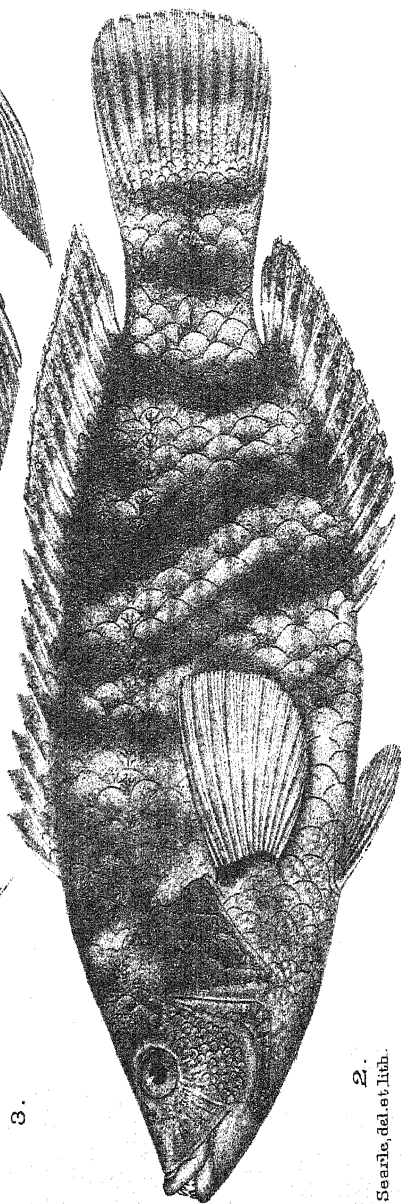




1.



3.



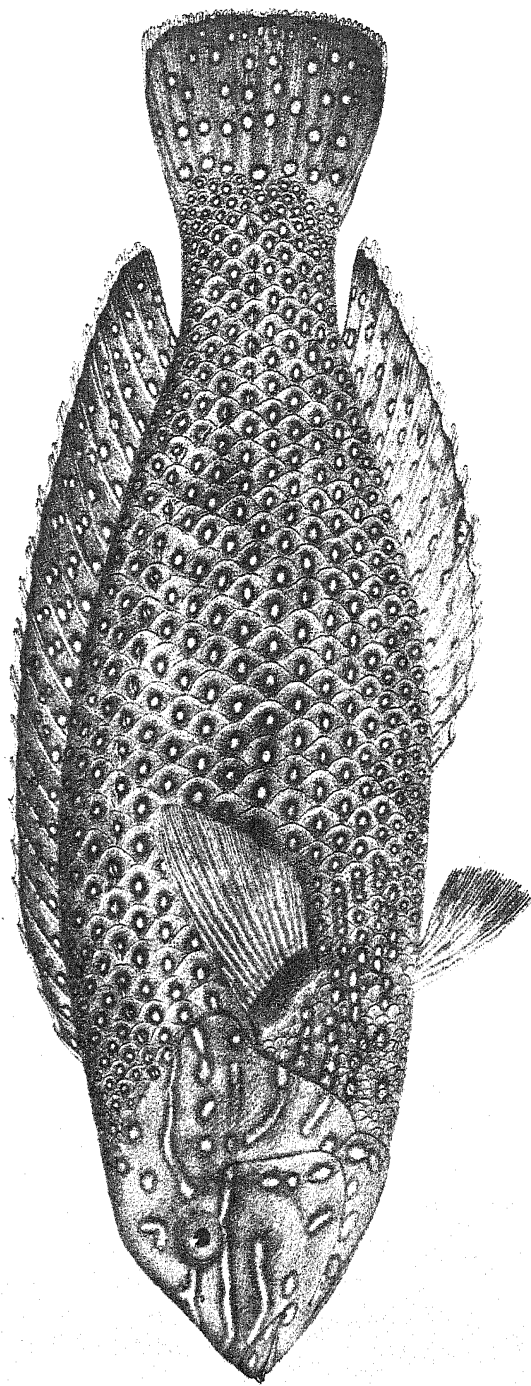
2.

A.H. Searle, del. et lith.

Huth, imp.

1. POMACENTRUS INORNATUS. 2. LABRICHTHYS FUENTESI.  
3. ANAMPSES PULCHER.





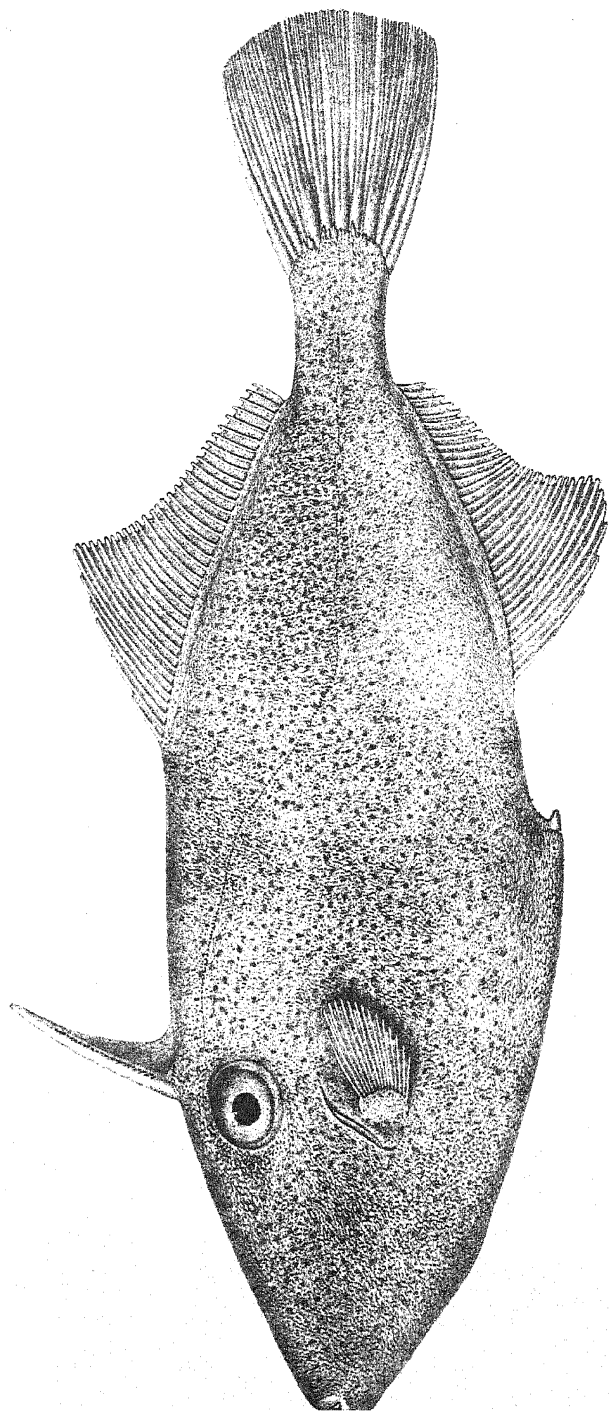
A. H. Searle, del et lith.

ANAMPSES PULCHER.

Hubb, imp.







A. H. Searle, del. et lith.

PSEUDOMONACANTHUS PASCHALIS.

Hutch, imp.



of head. Pectorals and pelvics subequal, a little more than  $\frac{1}{2}$  length of head. Caudal rounded. Dark brownish.

A single specimen, 230 mm. in total length.

This species is very closely related to *A. cinctus* Günth. from Norfolk Island, described from a specimen of nearly the same size. Comparison shows that *A. cinctus* differs in the larger head ( $2\frac{2}{5}$  in the length), higher dorsal fin (longest spines  $\frac{1}{3}$  the length of head), longer second anal spine ( $\frac{3}{8}$  the length of head), longer and stronger maxillary (extending to below posterior  $\frac{1}{4}$  of eye, its width  $\frac{7}{8}$  the diameter of eye), and the banded coloration.

#### KUHLIIDÆ.

##### 2. KUHLIA MUTABUNDA Kendall & Radcliffe. (Pl. LVI.)

Mem Mus. Comp. Zool. xxxv. 1912, p. 105, pl. iii. f. 1.

"Mahori."

Depth of body  $2\frac{2}{3}$  in the length, length of head  $3\frac{1}{5}$ . Snout  $\frac{2}{3}$  diameter of eye, which is  $2\frac{2}{3}$  in length of head; interorbital width  $3\frac{1}{3}$ . Lower jaw a little prominent; maxillary extending to below anterior  $\frac{1}{4}$  of eye; cheek with 4 series of ctenoid scales; angle and lower edge of præoperculum finely denticulated; 25 gill-rakers on lower part of anterior arch. 50 scales in the lateral line, 6 between sheath at base of anterior dorsal spines and lateral line, 13 from lateral line to pelvic fin. Dorsal X 11; fourth and fifth spines longest,  $\frac{1}{2}$  length of head; last  $\frac{1}{3}$  length of head, a little shorter than seventh, considerably shorter than longest soft rays. Anal III 11; third spine a little longer than second, as long as tenth dorsal; base of fin a little more than  $\frac{2}{3}$  length of head or  $1\frac{1}{4}$  its distance from caudal. Pectoral  $\frac{2}{3}$  length of head. Caudal deeply forked. Caudal peduncle  $1\frac{2}{3}$  as long as deep. Silvery, back darker; caudal blackish posteriorly.

A single specimen, 190 mm. in total length.

Related to *K. humilis* De Vis, from Queensland and the Fiji Islands, and to *K. sandwicensis* Steind., known from the Sandwich Islands and Society Islands.

#### GIRELLIDÆ.

##### GIRELLOPS, gen. nov.

Related to *Tephrocops*, but with uniserial teeth.

##### 3. GIRELLOPS NEBULOSUS Kendall & Radcliffe. (Pl. LVII.)

*Girella nebulosa* Kendall & Radcliffe, Mem. Mus. Comp. Zool. xxxv. 1912, p. 120, pl. iii. f. 2, pl. iv. ff. 1, 2.

"Maahaki."

Depth of body  $2\frac{2}{3}$  in the length, length of head 4. Diameter of eye 4 in length of head, interorbital width 2. Scales on cheeks, temporal region, and upper edge of operculum; rest of head naked. Teeth in jaws fixed, uniserial, incisor-like, the anterior

ones truncated, the lateral ones obtusely tricuspid; palate toothless; maxillary extending to below nostrils. Depth of præorbital  $\frac{3}{2}$  diameter of eye. Gill-membranes broadly united, forming a fold across isthmus. Dorsal XVI 12, scaly at the base; spines stout, subequal from the fifth to the last, which is  $\frac{1}{2}$  the length of head and a little shorter than the anterior soft rays. Anal III 10; second and third spines subequal,  $\frac{1}{2}$  length of head; second or third soft rays  $\frac{4}{5}$  as long as head. Caudal slightly emarginate. Pectoral as long as head. Scales ciliated, 78 in a longitudinal series, 12 or 13 between sheath at base of anterior dorsal spines and lateral line. Dark greyish, with traces of darker spots and markings.

The above description from a specimen of 270 mm. A young example, 43 mm. in total length, has the same number of scales and fin-rays, but all the teeth are tricuspid, and the markings obscurely indicated in the adult take the form of 7 dark cross-bars and scattered spots on the body, and longitudinal bands on the dorsal fin. The nearest ally of this species appears to be *Tephrocops richardsonii*, which ranges from New South Wales to Western Australia.

#### CARANGIDÆ.

##### 4. CARANX CHEILIO Snyder.

*Caranx guaru* (non Bonn.) Kendall & Radcliffe, Mem. Mus. Comp. Zool. xxxv. 1912, p. 99.

"Poopo."

Originally described from a specimen 30 inches long obtained in the market at Honolulu; the example now recorded from Easter Island is 12 inches long.

#### POMACENTRIDÆ.

##### 5. POMACENTRUS INORNATUS. (Pl. LVIII. fig. 1.)

"Cototi."

? *Pomacentrus niomatus* De Vis, Proc. Linn. Soc. N. S. Wales, viii. 1883, p. 451.

? *Pomacentrus inornatus* Seale, Bull. U.S. Fish. Bureau, xxv. 1905, p. 281.

*Pomacentrus jenkinsi* Kendall & Radcliffe, Mem. Mus. Comp. Zool. xxxv. 1912, p. 132.

Depth of body  $1\frac{1}{2}$  in the length, length of head  $3\frac{1}{2}$ . Snout a little shorter than eye, the diameter of which is  $3\frac{1}{2}$  in the length of head; interorbital width 3. Mouth subterminal. Head scaly, except lips and extremity of snout; 2 series of scales on cheek and 1 on lower limb of præoperculum. Præorbital entire; suborbitals and præoperculum denticulated. 28 scales in a longitudinal series, 20 in the lateral line, 3 between middle of spinous dorsal and lateral line. Dorsal XIII 16; spines subequal

from fourth to last, which is  $\frac{1}{2}$  length of head; middle soft rays nearly as long as head. Anal II 13. Pectoral as long as head. Caudal deeply emarginate. Caudal peduncle much deeper than long. Brownish; scales black-edged; vertical fins blackish; a small blackish spot above axil of pectoral.

A single specimen, 100 mm. in total length.

De Vis's description is so incomplete that it is impossible to identify his species with certainty. He described it as probably from the South Seas, and Seale has recorded this, or a related species, from Samoa. *P. jenkinsi*, from the Sandwich Islands, as described and figured by Jordan and Evermann, seems to have a broader and more convex interorbital region, deeper præorbital, and less deeply emarginate caudal fin.

#### LABRIDÆ.

##### 6. CHEILIO INERMIS Forsk.

"Ure-ure."

A species of wide distribution, ranging from Africa to the Western Pacific.

##### 7. JULIS UMBROSTIGMA Rüpp.

"Pacoju."

This also occurs throughout the tropical Indo-Pacific.

##### 8. LABRICHTHYS FUENTESI, sp. n. (Pl. LVIII. fig. 2.)

*Pseudolabrus inscriptus* (non Richards.) Kendall & Radcliffe, Mem. Mus. Comp. Zool. xxxv. 1912, p. 137, pl. v. f. 2, pl. vi. f. 1.

"Cootea."

Depth of body  $2\frac{2}{3}$  in the length, length of head  $3\frac{1}{2}$ . Snout  $1\frac{2}{3}$  as long as diameter of eye, which is  $5\frac{1}{2}$  in the length of head and a little less than the interorbital width. Upper jaw with a posterior canine on each side and a pair of strong anterior canines; lower with 2 pairs of anterior canines; cheek with 5 series of scales. 25 scales in the lateral line. Dorsal IX 11; scales extending on to basal part of fin. Anal III 10. Pectoral  $\frac{2}{3}$  length of head. Caudal subtruncate. Body with about 8 irregular cross-bars ending in blotches on basal part of dorsal fin; head and upper part of body with numerous small pale spots or vermiculations; soft dorsal and anal with broad marginal dark bands including numerous pale spots with dark centres; base of pectoral fin blackish.

A single specimen, 165 mm. in total length.

This species is nearest to *L. luculenta* Richards., from Norfolk Island and Australia.

##### 9. ANAMPSES PULCHER, sp. n. (Pl. LVIII. fig. 3 & Pl. LIX.)

"Mouri."

Depth of body  $2\frac{3}{4}$  in the length, length of head  $3\frac{1}{2}$ . Diameter  
Proc. Zool. Soc.—1913, No. XXVI. 26

of eye 7 in length of head,  $2\frac{1}{2}$  in length of snout. Interorbital region strongly convex, its width  $\frac{1}{3}$  the length of head. A naked strip running backwards from occiput to origin of dorsal fin. 28 scales in the lateral line. Dorsal IX 12. Anal III 12. Pectoral  $\frac{3}{4}$  the length of head. Caudal subtruncate. Each scale with a blue spot surrounded by a dark ring; head with blue horizontal stripes or series of spots; one through upper part of eye; another from end of snout through lower edge of eye, a third across the cheek; vertical fins with spots like those on the body and with a narrow pale blue or white margin; base of pectoral blackish.

A specimen of 205 mm., from Easter Island, differs from one of the same size of *A. cæruleopunctatus* Rüpp. of the tropical Indo-Pacific, especially in the broader and more convex interorbital region, the incompletely scaled nape, and the different coloration of the head, *A. cæruleopunctatus* having vertical stripes running from eye to suboperculum.

A second example of *A. pulcher*, 165 mm. in total length, from Tahiti (*Wragge*), is extremely similar to the type, but has the interorbital region less convex, and the naked median strip on the nape less elongate, not quite reaching the dorsal fin.

#### BLENNIIDÆ.

##### 10. SALARIAS ARENATUS Bleek.

*Alticus striatus* (? Cuv. & Val.) Kendall & Radcliffe, Mem. Mus. Comp. Zool. xxxv. 1912, p. 134.

"Patuki."

A species of the East Indian Archipelago and Islands of the South Pacific.

#### BALISTIDÆ.

##### 11. PSEUDOMONACANTHUS PASCHALIS, sp. n. (Pl. LX.)

"Coreba."

Scales small, irregular, covered with minute spines. Depth of body  $2\frac{3}{4}$  in the length. Snout produced, with upper profile a little convex, more than 3 times as long as eye and a little less than  $\frac{1}{4}$  the length of the fish. Lower angle of gill-opening below anterior margin, base of pectoral below middle of eye. Dorsal spine nearly as long as snout, above posterior  $\frac{1}{2}$  of eye, antero-posteriorly compressed, with a series of 24 small barbs on each side; soft dorsal of 35 rays, elevated anteriorly; anal rays 34. Caudal rounded. Greyish, with numerous scattered small dark spots.

A single specimen, 300 mm. in total length.

This species is related to the Australian *P. ayraudi* Quoy & Gaim.

## EXPLANATION OF THE PLATES.

## PLATE LV.

*Acanthistius fuscus.*

## PLATE LVI.

*Kuhlia mutabunda.*

## PLATE LVII.

*Girellops nebulosus.*

(a) Teeth. (b) Young.

## PLATE LVIII.

- Fig. 1. *Pomacentrus inornatus*.  
 2. *Labrichthys fuentesi*.  
 3. *Anampses pulcher*; head of specimen from Tahiti.

## PLATE LIX.

*Anampses pulcher.*

## PLATE LX.

*Pseudomonacanthus paschalis.*

## APPENDIX.

[It was not until the above was in the press and the plates had been drawn, that I saw Kendall and Radcliffe's recent memoir on fishes from the eastern tropical Pacific. I have altered my paper only by taking their names for the new species of *Kuhlia* and *Girellops* and by inserting references to their work when our determinations did not coincide. They obtained nine of the eleven species, all but *Anampses pulcher* and *Pseudomonacanthus paschalis*. They also got a number of other species from Easter Island mostly known previously from the tropical Pacific, viz. *Myripristis pralinus* Cuv. & Val., *Holocentrum punctatissimum* Cuv. & Val., *Decapterus sanctæ-helenæ* Cuv. & Val., *Cyphosus cinerascens* Forsk., *Pseudupeneus multifasciatus* Quoy & Gaim., *Thalassoma purpureum* Forsk., *Teuthis umbra* Jenkins, *Kellogella oligolepis* Jenkins, *Alticus variolosus* Cuv. & Val., and *Xanthichthys lineopunctatus* Hollard. The identification of a species of *Monacanthus* with the Japanese *M. cirrifer* Schleg. seems open to question, and still more so the determination of an Eel as *Gymnothorax dovii* Günth., as the type from Panama appears to differ in many respects from the specimens from Easter Island, which, from the data given, seem more like the Indo-Pacific *G. meleagris* Shaw.

Finally, the resemblance to Norfolk Island is increased by the addition of two species—the one, *Trachypomamaeracanthus* Günth., apparently not distinct from the Norfolk Island form, the other a *Bathystethus*, requiring a new specific name.

## BATHYSTETHUS ORIENTALE, sp. n.

*Platystethus cultratum* (non Schneid.) Kendall & Radcliffe, Mem. Mus. Comp. Zool. xxxv. 1912, p. 97, pl. ii. f. 3.

Closely related to *B. cultratum*, but head longer, 4 in length

of fish ( $4\frac{1}{2}$  in *B. cultratum*), eye larger,  $3\frac{1}{2}$  in length of head or nearly equal to its distance from edge of lower limb of præoperculum ( $4\frac{1}{2}$  in head and  $1\frac{1}{2}$  in its distance from lower edge of præoperculum in *B. cultratum*), and fin-rays more numerous. Dorsal VIII, I 27; anal III 32 (VIII, I 23-25 and III 28-30 in *B. cultratum*).

The type from Easter Island measures about 200 mm. in total length (to end of middle caudal rays), the examples of *B. cultratum* from Norfolk Island that I have examined 170 to 180 mm.]

## 28. A Revision of the Fishes of the Genus *Kuhlia*.

By C. TATE REGAN, M.A., F.Z.S.

[Received March 4, 1913: Read April 8, 1913.]

(Text-figures 68 & 69.)

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<i>K. sauravii</i> , sp. n. ....	377
<i>K. splendens</i> , sp. n. ....	379

I have been led to undertake a revision of the species of the Indo-Pacific genus *Kuhlia* Gill, owing to the difficulty I experienced in determining the correct name for a fish of this genus from Easter Island (*Kuhlia mutabunda*).

To the synonymy of *Kuhlia* as given by Boulenger (Cat. Fish. i. p. 36) may be added *Boulengerina* (non Dollo) Fowler (Proc. Acad. Philad. 1906, p. 512), and *Safole* Jordan (Proc. U.S. Nat. Mus. xlii. 1912, p. 655).

These names are intended to distinguish the more silvery and more strictly marine species with more numerous gill-rakers (*Safole*) from the spotted forms that enter rivers and have fewer gill-rakers (*Kuhlia*). There is but little justification for such a generic division. *K. boninensis* is intermediate between the two groups in the number of gill-rakers; *K. marginata* may sometimes be unspotted, and in the form and coloration of the caudal fin is nearer to *K. humilis* than to *K. rupestris*, and *K. splendens*, a silvery, unspotted species, with numerous gill-rakers, is described below from the fresh-waters of Rodriguez.

### *Synopsis of the Species.*

- I. Lateral line of 40 to 45 scales (+ 4 or 5 on base of caudal fin); 16 to 19 gill-rakers on lower part of anterior arch; body usually spotted.
  - A. Caudal fin slightly emarginate; middle rays  $\frac{2}{3}$  or  $\frac{3}{4}$  as long as longest; lobes rounded. Dorsal X 11. Anal III 10.
    1. Maxillary extending to below middle of eye (young or beyond (adult) ..... 1. *rupestris*.
    2. Maxillary not or barely reaching middle of eye in adult.



- Upper opercular spine nearly as strong as lower; dorsal origin in advance of pelvis..... 2. *cærulescens*.
- Lower opercular spine much the stronger; dorsal origin above base of pelvis ..... 3. *sauvagii*.
- B. Caudal fin more deeply emarginate; middle rays  $\frac{1}{2}$  to  $\frac{3}{5}$  as long as longest; lobes pointed. Dorsal X 10-12. Anal III 11-13.
- Maxillary extending beyond middle of eye ..... 4. *uvrillii*.
- Maxillary not or barely reaching middle of eye ..... 5. *marginata*.
- II. Lateral line of 46 to 56 scales (+ 4 or 5 on base of caudal fin); no spots on body.
- A. 21 or 22 gill-rakers on lower part of anterior arch ... 6. *boninensis*.
- B. 24 to 29 gill-rakers on lower part of anterior arch.
1. Dorsal X 13-14. Anal III 12-13 ..... 7. *caudorittata*.
2. Dorsal X 11. Anal III 11; caudal fin plain, usually with dark posterior margin.
- a. Middle caudal rays more than  $\frac{1}{2}$  as long as longest; 4 scales from sheath at base of spinous dorsal to nearest part of lateral line.
- Eye a little shorter than postorbital part of head ..... 8. *splendens*.
- Eye as long as postorbital part of head ..... 9. *humilis*.
- b. Middle caudal rays less than  $\frac{1}{2}$  as long as longest; 5 or 6 scales from sheath at base of spinous dorsal to nearest part of lateral line.
- Anal nearly as long as head, much longer than caudal peduncle ..... 10. *sandricensis*.
- Anal  $\frac{2}{3}$  length of head, a little longer than caudal peduncle ... 11. *mutabunda*.
3. Dorsal X 9-11. Anal III 10-11. Caudal fin with five blackish bands, one median and two on each lobe ..... 12. *tæniura*.

## 1. KUHLLIA RUPESTRIS.

*Centropomus rupestris* Lacep. Hist. Nat. Poiss. iv. pp. 252, 273 (1802).

*Kuhlia rupestris* (part.) Bouleng. Cat. Fish. i. p. 36 (1895).\*

*Kuhlia rupestris hedleyi* Ogilby, Proc. Linn. Soc. N. S. Wales, xxii. 1897, p. 767.

Depth of body  $2\frac{1}{2}$  to 3 in the length, length of head  $2\frac{3}{4}$  to  $3\frac{1}{2}$ . Snout  $\frac{3}{4}$  to  $1\frac{1}{2}$  diameter of eye, which is  $3\frac{1}{4}$  to  $5\frac{1}{2}$  in length of head; interorbital width 3 to  $3\frac{2}{3}$ . Maxillary extending to below middle of eye (young) or beyond. 16 to 19 gill-rakers on lower part of anterior arch. 40 to 44 scales in lateral line, 4 or  $4\frac{1}{2}$  from scaly sheath at base of spinous dorsal to highest part of lateral line, 9 to 11 thence to base of pelvic fin. Dorsal X 11; fourth or fifth spine longest,  $\frac{1}{3}$  to more than  $\frac{1}{2}$  length of head; last as long as sixth, seventh, or eighth,  $\frac{2}{7}$  to more than  $\frac{2}{5}$  length of head. Anal III 10; third spine usually shorter than tenth dorsal; base  $\frac{2}{3}$  to  $\frac{1}{2}$  length of head, longer than caudal peduncle. Pectoral  $\frac{1}{2}$  to  $\frac{2}{3}$  length of head. Caudal peduncle as long as, or longer than, deep. Bluish silvery; each scale usually with a dark spot; each lobe of caudal and soft dorsal with a blackish

\* The synonymy is as given by Boulenger, except for *Dules fuscus* of Sauvage, which is a distinct species.

or brownish spot in young, these spreading to form broad marginal bands in adult; soft dorsal and upper and lower margins of caudal often narrowly edged with white; soft vertical fins usually with one or more series of spots.

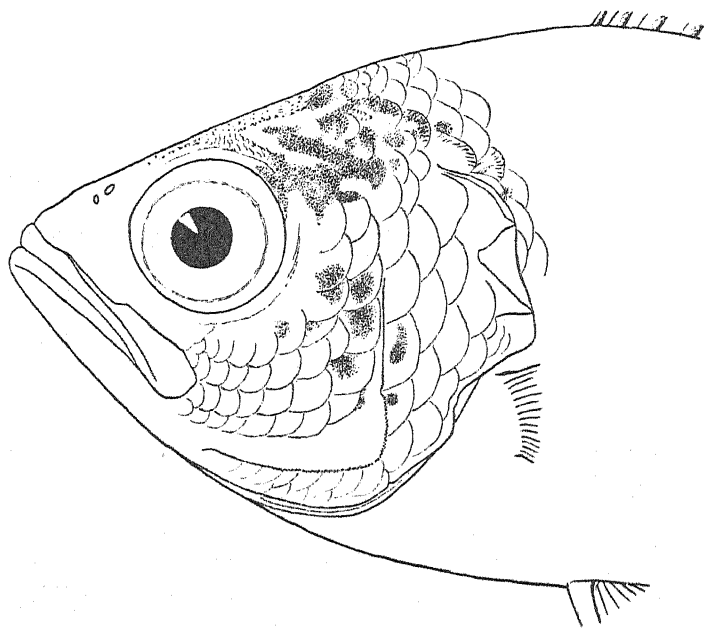
Indo-Pacific, from Africa to the Paumotu Archipelago. Twenty-six specimens, 85 to 400 mm. in total length.

2. *KUHILIA CÆRULESCENS*, sp. n. (Text-fig. 68.)

*Kuhlia rupestris* (part.) Bouleng. Cat. Fish. i. p. 36 (1895).

Depth of body 3 in the length, length of head  $3\frac{1}{5}$ . Snout  $\frac{3}{4}$  diameter of eye, which is  $3\frac{2}{5}$  in length of head; interorbital width  $3\frac{1}{3}$ . Maxillary extending to below middle of eye; upper opercular spine nearly as strong as lower; 7 gill-rakers on lower part of anterior arch. 41 scales in lateral line,  $4\frac{1}{2}$  from sheath at base of

Text-fig. 68.



Head of *Kuhlia caerulea*.

spinous dorsal to highest part of lateral line,  $9\frac{1}{2}$  thence to base of pelvic fin. Dorsal X 11; origin in advance of base of pelvics; fifth spine longest,  $\frac{2}{5}$  length of head; last as long as seventh,  $\frac{3}{8}$  length of head. Anal III 10; third spine  $\frac{1}{3}$  length of head; base  $\frac{3}{4}$  length of head or  $1\frac{2}{5}$  as long as caudal peduncle. Pectoral less than  $\frac{3}{5}$  length of head. Caudal slightly emarginate, with rounded lobes. Caudal peduncle  $1\frac{1}{3}$  as long as deep. Bluish

silvery; a dark spot at base of each scale; cheeks and opercles spotted; soft dorsal and anal with longitudinal bands or series of spots; caudal with broad dark band posteriorly.

Solomon Islands.

A single specimen, 290 mm. in total length, from Stirling Island.

This species is near *K. sauvagii*, but has the coloration of *K. rupestris*. Sauvage's figure of the former agrees with the example in the British Museum collection, and differs from the type of *K. caerulea* in the much smaller upper opercular spine and the more posterior origin of the dorsal fin.

### 3. KUHLIA SAUVAGII, sp. n.

*Dules fuscus* (non Cuv. & Val.) Sauvage, Hist. Madag., Poiss. p. 149, pl. xv. f. 4 (1891).

?*Moronopsis fuscus* Steind. Sitzungsab. Akad. Wien, lxxxii. 1881, p. 240.

Depth of body  $2\frac{2}{3}$  in the length, length of head  $3\frac{1}{3}$ . Snout  $\frac{2}{3}$  as long as diameter of eye, which is 3 in the length of head and equal to the interorbital width. Maxillary extending to below anterior  $\frac{1}{3}$  of eye; lower opercular spine much stronger than upper; 16 or 17 gill-rakers on lower part of anterior arch. 44 scales in lateral line, 4 between sheath at base of spinous dorsal and arch of lateral line, 10 thence to base of pelvic fin. Dorsal X 11; origin above base of pelvics; fifth spine longest,  $\frac{2}{3}$  length of head; last nearly as long as seventh,  $\frac{1}{2}$  length of head. Anal III 10; base nearly as long as head or nearly twice as long as caudal peduncle; third spine less than  $\frac{1}{2}$  length of head. Pectoral  $\frac{3}{4}$  length of head. Caudal slightly emarginate. Caudal peduncle a little longer than deep. Silvery, back darker; sides with scattered rounded or crescentic reddish-brown spots; soft dorsal and anal spotted; caudal with dark membrane and pale rays.

Madagascar.

The above description is based on a single specimen, 150 mm. in total length, from Imerina, Madagascar, which evidently belongs to the same species as the example of 300 mm., also from Madagascar, figured by Sauvage. This larger fish has, of course, shorter spines, a smaller eye, etc., and in it the maxillary almost reaches the vertical from the middle of the eye.

Dr. Pellegrin has kindly examined the types of *Dules fuscus* Cuv. & Val., two examples only 4 inches long, and writes that the maxillary extends slightly beyond the vertical from the middle of the eye. There can be little doubt but that these are specimens of *K. rupestris*.

### 4. KUHLIA URVILLII.

*Kuhlia urvillii* Bouleng. Cat. Fish. i. p. 38 (1895).

This species is based on a coloured figure in Dumont D'Urville's 'Voyage au Pôle Sud,' which represents a fish of 160 mm. very similar to *K. marginata*, but with the last dorsal spine longest of

all,  $\frac{2}{3}$  the length of head, and with the maxillary extending to below the posterior part of the eye.

### 5. KUHLLIA MARGINATA.

*Dules marginatus* Cuv. & Val. Hist. Nat. Poiss. iii. p. 116, pl. ii. (1829).

*Dules maculatus* Cuv. & Val. op. c. vol. vii. p. 475 (1831).

*Dules malo* Cuv. & Val. t. c. p. 479.

*Dules mato* Lesson, Voy. Coquille, Zool. ii. p. 223 (1831).

*Dules leuciscus* Jenyns, Zool. Beagle, Fish. p. 17 (1842).

*Kuhllia marginata* Boulenger, Cat. Fish. i. p. 38 (1895) (with synonymy).

*Kuhllia malo* Kendall & Goldsborough, Mem. Mus. Comp. Zool. xxvi. 1911, p. 280, pl. ii. f. 2.

*Kuhllia maculata* Kendall & Goldsborough, t. c. p. 281, pl. iii. f. 1.

Depth of body  $2\frac{3}{5}$  to  $3\frac{1}{5}$  in the length, length of head 3 to  $3\frac{1}{2}$ . Snout  $\frac{1}{2}$  to  $\frac{3}{4}$  diameter of eye, which is  $2\frac{2}{3}$  to  $3\frac{1}{3}$  in length of head; interorbital width 3 to  $3\frac{2}{3}$ . Maxillary extending to below anterior  $\frac{1}{5}$  of eye. 16 to 18 gill-rakers on lower part of anterior arch. 40 to 45 scales in lateral line, 4 or  $4\frac{1}{2}$  from sheath at base of spinous dorsal to highest part of lateral line, 8 or 9 thence to base of pelvic fin. Dorsal X 10-12; fifth spine usually longest,  $\frac{1}{2}$  to  $\frac{2}{3}$  length of head; last as long as sixth, seventh, or eighth,  $\frac{2}{5}$  to more than  $\frac{3}{5}$  length of head. Anal III 11-13; third spine shorter than tenth dorsal; base nearly as long as head, nearly twice as long as caudal peduncle. Pectoral  $\frac{3}{5}$  to  $\frac{2}{3}$  length of head. Caudal moderately emarginate, the middle rays  $\frac{1}{2}$  to  $\frac{3}{5}$  as long as longest. Caudal peduncle longer than deep. Silvery, usually dark spotted above lateral line and sometimes below it; soft dorsal and anal dark edged, at least anteriorly, often dark spotted basally; caudal with dark posterior margin and with dark spots or a band parallel to posterior edge; soft dorsal, anal, and upper and lower margins of caudal often narrowly edged with white; pelvics sometimes spotted.

Malay Archipelago and South Pacific.

Numerous examples, 75 to 160 mm. in total length, including the types of *D. leuciscus*, kindly lent to me by Mr. L. Doncaster.

Some examples are almost covered with spots, others are silvery with scarcely a trace of spots, the variation in this respect recalling our British Trout; probably the silvery examples are marine, whilst the strongly spotted ones may have been for a long time in fresh water.

### 6. KUHLLIA BONINENSIS.

*Kuhllia caudovittata* (part.) Bouleng. Cat. Fish. i. p. 41 (1895).

*Dules marginatus boninensis* Fowler, Proc. Acad. Philad. lviii. 1906, p. 510, fig.

Depth of the body nearly 3 in length, length of head  $3\frac{1}{3}$ . Snout

$\frac{3}{4}$  diameter of eye, which is 3 in length of head; interorbital width  $3\frac{1}{4}$ . Maxillary extending to below anterior  $\frac{1}{4}$  of eye. 22 gill-rakers on lower part of anterior arch. 52 scales in lateral line, 5 from sheath at base of spinous dorsal to arch of lateral line, 12 thence to base of pelvic fin. Dorsal X 11; fifth spine longest, a little more than  $\frac{1}{2}$  length of head; last as long as eighth,  $\frac{1}{3}$  length of head. Anal III 12; base as long as head or  $1\frac{1}{2}$  as long as caudal peduncle. Pectoral  $\frac{2}{3}$  length of head. Caudal forked, the middle rays  $\frac{1}{2}$  as long as the longest. Caudal peduncle  $1\frac{2}{3}$  as long as deep. Silvery; back darker; caudal with dark posterior edge and pale intramarginal band.

Eastern Pacific.

Here described from a specimen of 190 mm. from Tahiti; this is not so deep in the body as Fowler's type, a specimen of about 115 mm. from the Bonin Islands. Otherwise, making allowance for differences due to size, the two examples agree perfectly.

#### 7. KUHLLIA CAUDOVITTATA.

*Holocentrus caudovittatus* Lacep. Hist. Nat. Poiss. iv. pp. 332, 367 (1802).

*Dules caudovittatus* Cuv. & Val. Hist. Nat. Poiss. iii. p. 117 (1829) and vii. p. 475 (1835); Sauv. Hist. Madag., Poiss. p. 151, pl. xviii. f. 3 (1891).

*Kuhllia caudovittata* (part.) Bouleng. Cat. Fish. i. p. 41 (1895).

Evidently related to *K. humilis*, *sandvicensis*, etc., but distinguished by a small head, the subequal ninth and tenth dorsal spines, and the increased number of soft rays, 13 or 14 in the dorsal, 12 or 13 in the anal.

Madagascar and Mauritius.

Total length 225 mm.

#### 8. KUHLLIA SPLENDENS, sp. n. (Text-fig. 69 B.)

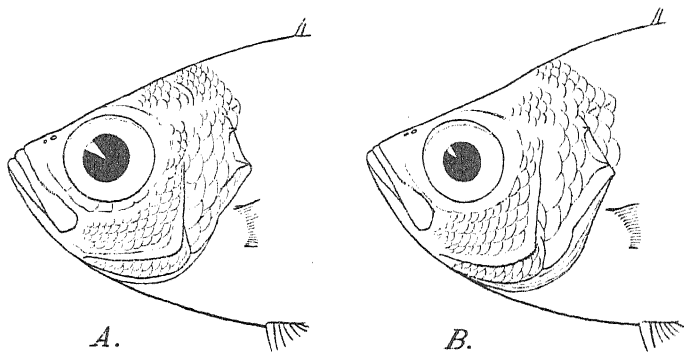
*Kuhllia malo* (part.) Bouleng. Cat. Fish. i. p. 40 (1895).

Depth of body  $2\frac{1}{2}$  to  $2\frac{3}{4}$  in the length, length of head 3 to  $3\frac{1}{3}$ . Snout  $\frac{3}{5}$  to  $\frac{2}{3}$  diameter of eye, which is 3 in length of head; interorbital width about  $3\frac{1}{2}$ . Maxillary extending to below anterior  $\frac{1}{4}$  of eye. 26 or 27 gill-rakers on lower part of anterior arch. 48 to 50 scales in lateral line, 4 from sheath at base of spinous dorsal to arch of lateral line, 11 thence to base of pelvic fin. Dorsal X 11; fourth or fifth spine longest, nearly  $\frac{2}{3}$  length of head; last as long or longer than eighth, nearly  $\frac{1}{2}$  length of head. Anal III 11; third spine a little shorter than tenth dorsal; base a little shorter than head or  $1\frac{2}{3}$  as long as caudal peduncle. Pectoral  $\frac{2}{3}$  length of head. Caudal deeply emarginate, but middle rays more than  $\frac{1}{2}$  as long as the longest. Caudal peduncle longer than deep. Silvery; back darker; caudal with blackish posterior edge.

Four specimens, 120 to 180 mm. in total length, from Rodriguez (fresh water) and Mauritius.

A small stuffed specimen from South Africa also belongs to this species.

Text-fig. 69.



Heads of (A) *Kuhlia humilis* and (B) *Kuhlia splendens*, in each case from a specimen 120 mm. in total length.

9. *KUHLIA HUMILIS*. (Text-fig. 69 A.)

*Kuhlia humilis* De Vis, Proc. Linn. Soc. N. S. Wales, ix. 1884, p. 396; Ogilby, Ann. Queensland Mus. x. 1911, p. 46, pl. vi. f. 1.

*Kuhlia malo* (part.) Bouleng. Cat. Fish. i. p. 40 (1895).

*Kuhlia proxima* Kendall & Goldsborough, Mem. Mus. Comp. Zool. xxvi. 1911, p. 282, pl. iii. f. 2.

Depth of body  $2\frac{3}{5}$  to 3 in the length, length of head 3 to  $3\frac{1}{4}$ . Snout  $\frac{1}{2}$  to  $\frac{2}{5}$  diameter of eye, which is  $2\frac{1}{2}$  to  $2\frac{3}{5}$  in length of head; interorbital width  $3\frac{1}{4}$  to  $3\frac{1}{2}$ . Maxillary extending to below anterior  $\frac{1}{4}$  of eye. 25 gill-rakers on lower part of anterior arch. 46 to 50 scales in lateral line, 4 from sheath at base of spinous dorsal to arch of lateral line, 10 or 11 thence to base of pelvic fin. Dorsal X 11; fourth or fifth spine longest,  $\frac{2}{3}$  length of head; tenth a little shorter than seventh, more than  $\frac{2}{5}$  length of head. Anal III 11; third spine as long as or a little longer than second, as long as tenth dorsal; base of fin nearly  $\frac{3}{4}$  as long as head or  $1\frac{1}{2}$  as long as caudal peduncle. Pectoral  $\frac{2}{3}$  length of head. Caudal deeply emarginate, but middle rays more than  $\frac{1}{2}$  as long as longest. Caudal peduncle  $1\frac{1}{3}$  as long as deep. Silvery; back darker; caudal with a rather broad dark posterior margin.

Queensland; Fiji Islands.

Three specimens, 90 to 120 mm. in total length, from Fiji, are undoubtedly *K. proxima*, but this seems to be a synonym of the Queensland *K. humilis*. The species is scarcely distinct from the preceding, but has a larger eye, the anal fin a little shorter, and the blackish margin of the caudal fin broader.

## 10. KUHLLIA SANDVICENSIS.

*Moronopsis argenteus*, var. *sandvicensis* Steind. Sitzungsab. Akad. Wien, lxxiv. 1876, p. 205.

*Moronopsis sandvicensis* Steind. *ib.* xvi. 1887, p. 56, pl. i. f. 1.

*Kuhllia malo* (part.) Bouleng. Cat. Fish. i. p. 40 (1895).

? *Kuhllia xenura* Jord. & Everm. Bull. U.S. Nat. Mus. xvii. 1896, p. 1015.

Depth of body  $2\frac{2}{3}$  to  $2\frac{4}{5}$  in the length, length of head  $3\frac{1}{3}$  to  $3\frac{2}{3}$ . Snout  $\frac{3}{5}$  to  $\frac{2}{3}$  diameter of eye, which is  $2\frac{2}{3}$  to 3 in length of head; interorbital width  $3\frac{1}{3}$  to 4. Maxillary extending to below anterior edge or anterior  $\frac{1}{4}$  of eye. 25 to 28 gill-rakers on lower part of anterior arch. 48 to 52 scales in lateral line, 5 or 6 from sheath at base of spinous dorsal to arch of lateral line, 11 to 13 thence to base of pelvic fin. Dorsal X 11; fifth spine longest,  $\frac{1}{2}$  to  $\frac{2}{3}$  length of head; last a little shorter than seventh,  $\frac{1}{3}$  to  $\frac{1}{2}$  length of head. Anal III 11; third spine as long as tenth dorsal; base of fin nearly as long as head or  $1\frac{2}{5}$  to  $1\frac{1}{3}$  as long as caudal peduncle. Pectoral  $\frac{2}{3}$  length of head. Caudal deeply forked, middle rays less than  $\frac{1}{2}$  as long as longest. Caudal peduncle  $1\frac{1}{5}$  to  $1\frac{1}{2}$  as long as deep. Silvery; back darker; caudal with narrow blackish posterior edge; dorsal and anal sometimes similarly margined.

Eastern Pacific.

Six specimens, 90 to 240 mm. in total length, from the Sandwich Islands and Tahiti.

## 11. KUHLLIA MUTABUNDA.

*Kuhllia mutabunda* Kendall & Radcliffe, Mem. Mus. Comp. Zool. xxxv. 1912, p. 105, pl. iii. f. 1.

This species from Easter Island, described above (p. 369, Pl. LVI.), differs from *K. sandvicensis* especially in the shorter anal fin.

## 12. KUHLLIA TENIURA.

*Dules teniurus* Cuv. & Val. Hist. Nat. Poiss. iii. p. 114 (1829).

*Kuhllia teniura* Bouleng. Cat. Fish. i. p. 39 (1895) (with synonymy).

*Kuhllia sterneckii* Steind. Sitzungsab. Akad. Wien, cvii. 1898, p. 461, pl.

This species is at once distinguished by the coloration of the caudal fin, with five black bands, a median longitudinal and two on each lobe. I am unable to regard Steindachner's *K. sterneckii* as distinct, for the relative length of the ninth and tenth dorsal spines varies considerably, and they are equal in 4 or 5 of the 20 specimens I have examined.

The species ranges throughout the Indo-Pacific, from Africa to the Revillagigedo Islands.

29. The Affinities of the Antarctic Wolf (*Canis antarcticus*).  
By R. I. Pocock, F.R.S., F.L.S., F.Z.S., Curator of  
Mammals.

[Received and Read April 8, 1913.]

(Text-figures 70-74.)

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The story of *Canis antarcticus* has been told by Darwin\*, by Hamilton Smith†, and more recently by Mr. Rupert Vallentin‡ from first-hand information, and by several authors indebted either to Darwin's or Hamilton Smith's account, or to the accounts of travellers who visited the Falklands before Darwin's time. References to the literature down to 1890 may be found in Mivart's 'Monograph of the Canidae,' published in that year. According to Mr. Vallentin, *Canis antarcticus* became extinct in 1876, without leaving a trace of its former existence in the Falkland Islands; and since all the known material of the species appears to be preserved in London and Paris, I have attempted to supply the want expressed by Allen§ by figuring a skull of one of the specimens in the British Museum. I have not, however, given detailed measurements of the skull, because these may be found in Mivart's monograph and in the paper by Huxley mentioned below.

Some six or seven years ago, when trying to identify some South American dogs exhibited in the Zoological Gardens, I took the incidental opportunity of looking at the skulls of a few of the species of Neotropical Canidae contained in the British Museum, to learn, if possible, something of their affinities to one another and to the better known species inhabiting North America and the countries of the Old World. Amongst the species examined were *Canis antarcticus*, the so-called Wolf of the Falkland Islands, and *Canis latrans*, the Coyote or Prairie Wolf, which ranges roughly from Canada to Mexico. The examination was made without any intention on my part of adding to the literature of the subject, with which I was only acquainted in a very general way; and after satisfying myself that *C. antarcticus* was related to certain Neotropical forms, of which *C. thous* (= *carnivorus*) may be taken as an example, and that the affinities of *C. latrans* lie with some of the so-called jackals and wolves of the Old World, I was contented to let the matter rest.

\* In Waterhouse's Zool. of H.M.S. 'Beagle,' Mammalia, p. 7, 1839.

† In Jardine's Nat. Libr., Mammalia, ix. p. 252.

‡ Manchester Memoirs, xlviii. p. 45, 1904. This paper is quoted by Mr. Lydekker, and some of the interesting and puzzling points connected with *C. antarcticus* are discussed in 'The Field,' Oct. 1, 1904.

§ Rep. Princeton Univ. Exped. Patagonia, iii. pt. 1, p. 153, 1905.



But in the summer of 1912, I received for review from the Editor of 'Nature' a copy of Dr. R. F. Scharff's volume, 'Distribution and Origin of Life in America,' 1911; and when I found it definitely stated therein that *C. antarcticus* is closely related to *C. latrans*, and when I saw the obvious difficulties in which Dr. Scharff was involved in his attempt to explain, on geographical grounds, this singular affiliation, I ventured to reassure him by remarking, in effect, that his belief was devoid of morphological foundation.

Now, an author who compiles a volume on zoology of the size and scope of the 'Distribution and Origin of Life in America' cannot be expected to verify all the statements of earlier and contemporary writers. Nor in the present instance could Dr. Scharff be justly criticised for not travelling to London to examine for himself the preserved material of *C. antarcticus*, of which, I take it, there is no specimen in Dublin. Very naturally, therefore, he trusted to the verdict of others, and promptly replied to my remark with a request for my reasons for making it. But since I could not ask the Editor of 'Nature' to give me the necessary space for justifying the statement I had made, I pledged myself to do this elsewhere, and the matter that follows is an attempt to redeem that promise.

The acknowledged source of Dr. Scharff's opinion about the mutual affinities of *C. antarcticus* and *C. latrans* was the following passage in Mr. Lydekker's 'Geographical History of Mammals,' 1896:—"Of the two indigenous mammals, the most remarkable is the Falkland Island Wolf (*Canis antarcticus*), which differs markedly from all the Canidæ of the mainland and is apparently closely allied to the North American Coyote (*C. latrans*)" (p. 140). I therefore wrote and asked Mr. Lydekker if he would kindly tell me his reasons for this conclusion, and he informed me that he took it from Prof. Huxley's classic paper upon the cranial and dental characters of the Canidæ, published in the 'Proceedings' of this Society, 1880, pp. 238-288. Upon looking up this paper I find the following passages referring to the two species under discussion and bearing upon the question at issue:—

- (1) . . . . . But sometimes there is a well-defined though comparatively narrow sagittal area, from the centre of which a low sagittal crest rises. This is well seen in some Jackals, and especially in *C. antarcticus* (p. 250).
- (2) In the large size of the upper molars . . . . . *C. antarcticus* presents the closest approximation to some specimens of *C. latrans* (p. 266).
- (3) From the range of variation of *C. cancrivorus* it can hardly be doubted that the examination of more extensive materials will prove the existence of an uninterrupted series of gradations from *C. vetulus* to *C. antarcticus* and *C. jubatus* (p. 266).
- (4) Seven crania of *C. latrans*, when measured, exhibit a considerable range of variation, though probably less than a larger series would show. But, as they are, I must confess myself unable to find an important break in the

series of gradations of cranial and dental structure between *Canis latrans* and *C. antarcticus* on the one hand, and *C. latrans* and *C. occidentalis* on the other. . . . . I may further remark that I can discern no difference of the slightest importance between skulls of *C. latrans* and those of some of our domestic dogs (pp. 272-273).

- (5) In the genus *Canis* we have . . . . . as a lowest section the species of the *C. cancrivorus* and *C. vetulus* type (answering pretty much to the Aguarra dogs of Hamilton Smith), the Sacaline section (*C. aureus*, *C. anthus*, *C. mesomelas*, *C. antarcticus*, *C. latrans*), and the Lupine section (*C. lupus* and all its varieties) (p. 286).

Whether these paragraphs justify Mr. Lydekker's statement \* that *C. antarcticus* differs markedly from all the Canidæ of the mainland of South America and is apparently closely allied to *C. latrans*, and Dr. Scharff's extension of this to the effect that *C. antarcticus* is certainly closely related to *C. latrans*, must be left to individual judgment.

Paragraph 1 merely points out one resemblance between *C. antarcticus* and some jackals. Paragraph 2 similarly points out one resemblance between the two species, but contains no suggestion of affinity between them. Paragraph 3 may be interpreted as suggesting affiliation between the extreme forms of South American Canidæ represented by *C. vetulus* and *C. jubatus*, with *C. antarcticus* lying midway between them. Paragraph 4 is more precise and states that there is no important structural break between *C. antarcticus* and *C. latrans*, and that the latter similarly intergrades with *C. occidentalis* and *C. familiaris*. Paragraph 5, on the contrary, definitely associates *C. antarcticus* and *C. latrans*, and at the same time severs the former from the group typified by *C. vetulus* and the latter from the group typified by *C. lupus* or *occidentalis*, an arrangement not easy to reconcile with the views expressed by paragraphs 3 and 4.

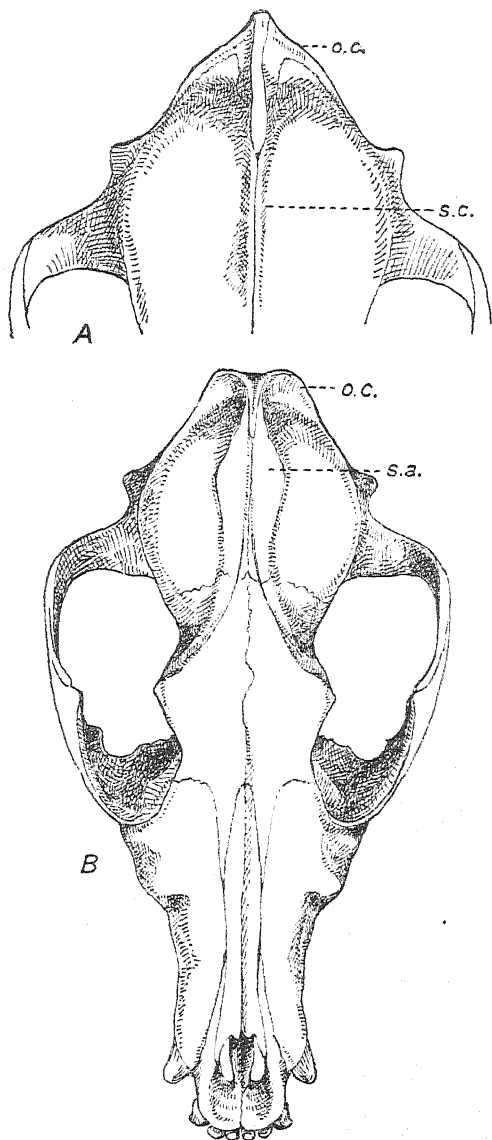
After reading Prof. Huxley's paper rather carefully for enlightenment on this subject, I must confess that I cannot form any clear idea as to his views of the affinities of the species he discussed, except in a broad sense.

If the substance of paragraphs 4 and 5 afford some justification for Mr. Lydekker's declaration respecting the relationship between *C. antarcticus* and *C. latrans*, it must be admitted that paragraph 3 does not support the contention that *C. antarcticus* is quite unrelated to the species of Canidæ inhabiting the South American mainland. However that may be, the conclusions forced upon me by the examination of five crania of *C. antarcticus* and twelve of *C. latrans* † in the British Museum and

\* In the article in 'The Field' (Oct. 1, 1904), above referred to, Mr. Lydekker evinces less assurance on these points; but he evidently could not bring himself to reject the authority of Huxley's opinion.

† I use this term in its old-fashioned and broad sense, disregarding the species or subspecies recently dismembered from *C. latrans* by American systematists.

Text-fig. 70.

A. Dorsal view of posterior part of skull of *Canis latrans*.B. Dorsal view of skull of *C. antarcticus*.

*o.c.*, occipital crest ; *s.c.*, sagittal crest ; *s.a.*, sagittal area.

The figures of the skull of *C. latrans* are from a specimen (♂) in the British Museum from Assiniboia (2.8.22), and those of *C. antarcticus* from a specimen in the British Museum (69.2.24.3).]

the Museum of the College of Surgeons are:—(1) that *C. antarcticus* and *C. latrans* are not closely allied; (2) that *C. antarcticus* is more nearly related to the *C. thous* (= *cancrivorus*) group of South American Canidae than to *C. latrans*; (3) that *C. latrans* must be affiliated with such Old World species as *C. pallipes*, *C. lupaster* and *C. anthus*, and not with *C. antarcticus*. The first and third of these conclusions are borne out by the external characters of the two species concerned. My reasons for these conclusions are as follows:—

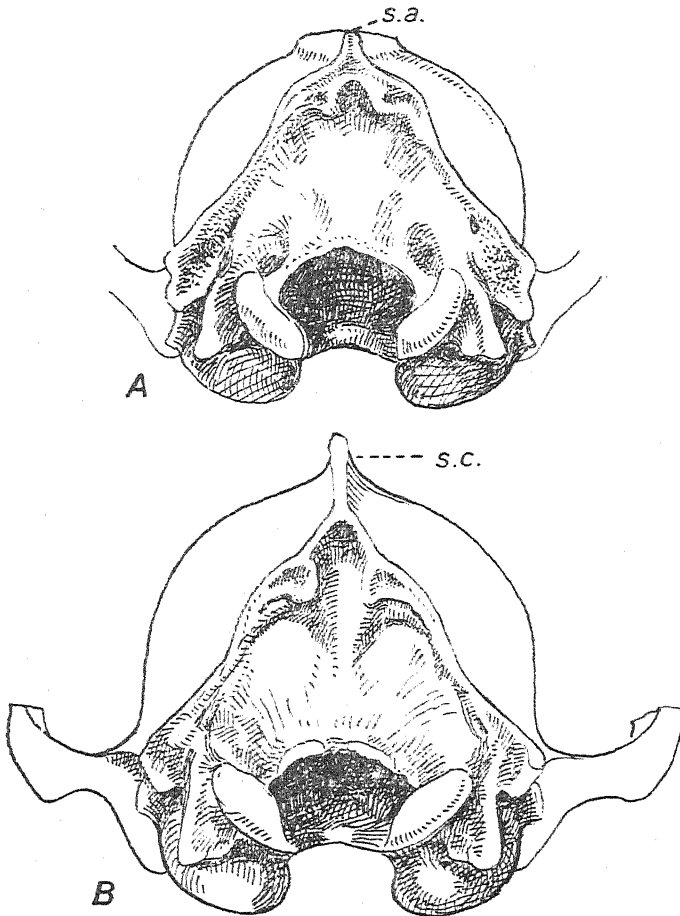
*The sagittal area and sagittal crest.*—As Huxley and Mivart have shown, the skull of *C. antarcticus* has a well-marked lyriform sagittal area which, according to the evidence of available crania, persisted throughout life, although in one of the three specimens in the British Museum it is decidedly narrower than in the two others. In the skulls of *C. latrans* that I have seen there is no distinct lyriform sagittal area, but in adult skulls there is a median cariniform sagittal crest varying in height with age. Even in two young skulls, in both of which the sphenoidal and occipital sutures are open, while one still retains a milk canine behind the permanent canine, there is no lyriform sagittal area. The significance of this depends upon the fact that the young of many species of Canidae of corresponding age or older show a stronger or weaker lyriform area corresponding with the sinuosity of the upspreading temporal muscle on each side, although in the young of no species of dog in which the adult possesses a cariniform sagittal crest does the lyriform sagittal area show, I believe, the development and definition it exhibits in the adult of *C. antarcticus*. However that may be, if *C. antarcticus* and *C. latrans* were closely related, we should at least expect to see a well-defined lyriform sagittal area in the skulls of subadult individuals of *C. latrans* killed before the temporal muscles had reached the summit of the cranium. But, as has been said, this area is remarkable for its indistinctness in immature skulls of that species.

*The occipital crest.*—In *C. antarcticus* the occipital crest, when viewed from above, is transversely truncated and not angular; when viewed from the side it only overhangs the vertical portion of the supraoccipital to a small extent; and when viewed from behind it forms a truncated angle. In *C. latrans* this crest is angularly produced backwards in the middle line, overhangs the occipital area to a much greater extent, and is more acutely angled from behind. It varies in shape and development in this species, but never, so far as I have seen, resembles that of *C. antarcticus* (text-figs. 70 & 71).

*The malar bone.*—In *Canis antarcticus* the anterior portion of the malar bone is marked by a strong masseteric ridge traversing approximately the middle of its outer surface; the inferior edge of the bone close to the maxilla is expanded convexly to afford additional support to the masseter muscle; its upper edge close to the maxilla is somewhat out-turned, forming a very appreciable hollow on the subjacent portion of the maxilla above the first

molar tooth. In *C. latrans* the masseteric crest of the malar is low down on its external surface, the inferior edge of the bone is scarcely at all expanded, so that the area for the attachment of

Text-fig. 71.

A. Occipital region of skull of *Canis antarcticus*.B. Occipital region of skull of *C. latrans*.

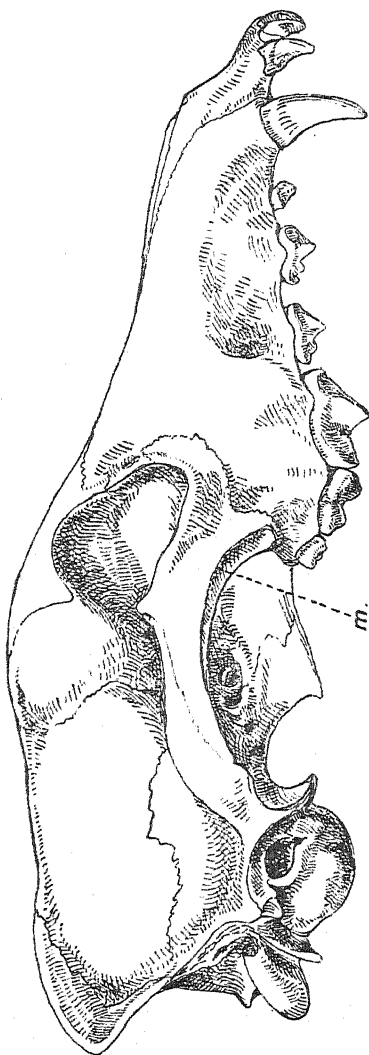
s.a., sagittal area; s.c., sagittal crest.

the masseter is much narrower than in *C. antarcticus*, and the upper edge of the malar is not noticeably out-turned, so that the hollow on the maxilla beneath it is less pronounced (text-figs. 72 & 73, pp. 388-9).

*Upper carnassial tooth.*—In *C. antarcticus* the antero-external Proc. Zool. Soc.—1913, No. XXVII.

cusps has the front border more rounded and the very fine crest that runs down it is defined on the inner side by a very indistinct groove. The antero-internal cusp is wider and rises further back and has no distinct little crest running inwards towards the

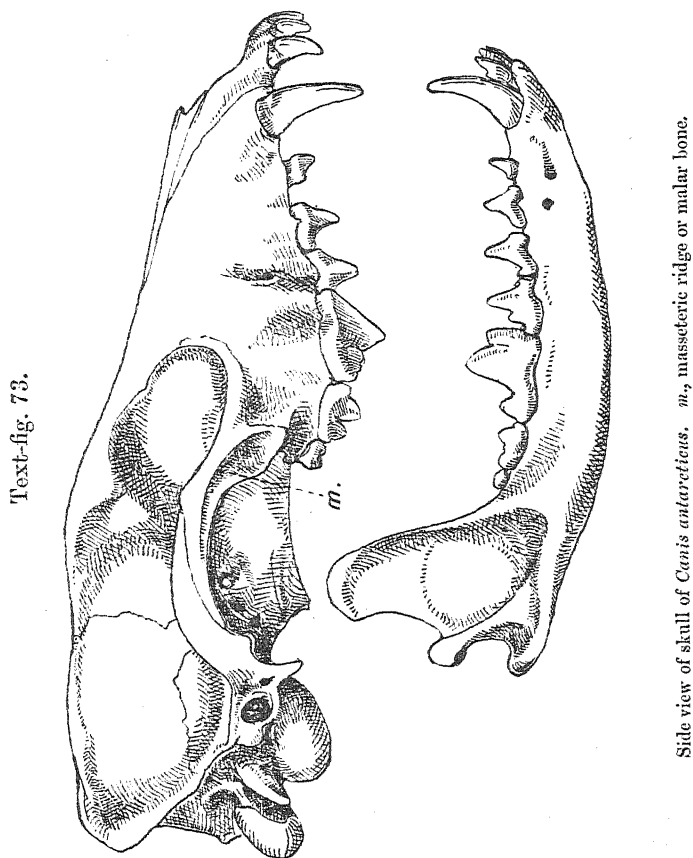
Text fig. 72.

Side view of skull of *Canis latrans*. *m.*, masseteric ridge or malar bone.

antero-external cusp. In *C. latrans* the crest traversing the anterior edge of the antero-external cusp is more pronounced and is defined by a distinct groove, the two combining to make the edge of this cusp more cutting than in *C. antarcticus*. The

antero-internal cusp is narrower and set distinctly more forwards than in *C. antarcticus*, and there is a delicate crest running along its surface towards the base of the antero-external cusp (text-fig. 74, A, B, p. 390).

*Lower carnassial tooth.*—The main cusp is higher and more pointed in *C. antarcticus* than in *C. latrans*, and the little cusp at its base on the inner side is much lower, so that it stands on a little higher level than the internal cusp of the talon. In *C. latrans*



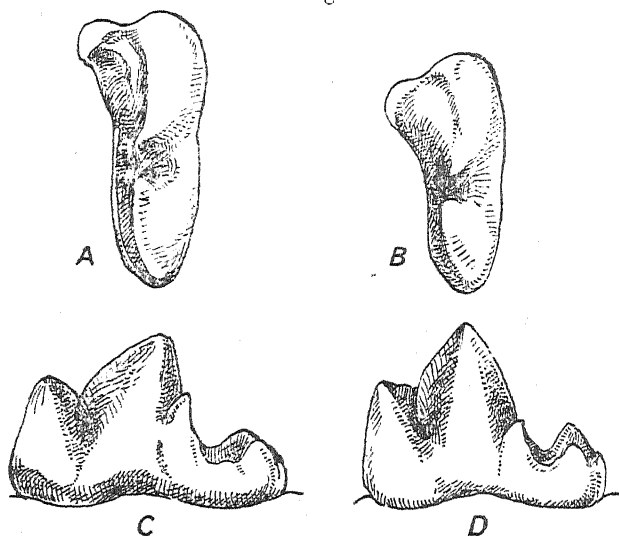
this cusp is comparatively high up the main cusp of the tooth and is considerably above the inner cusp of the talon (text-fig. 74, C, D, p. 390).

There are other minor differences both in the skull and teeth. The palatine bones, for instance, extend farther forwards with relation to the upper carnassials, and the margin of the posterior nares is also farther forwards with relation to the posterior molars in *C. latrans* than in *C. antarcticus*: the incisor teeth are

smaller and the crowns of the cheek-teeth are higher with relation to their breadth in *C. antarcticus* than in *C. latrans*. But apart from these, the principal differences mentioned above are quite sufficient to disprove the claim that the two species are closely related. According to modern standards of classification they are subgenerically, if not generically, distinct.

But the characters above described tell us more than that. Taking *C. latrans* first, it is obvious that in the cariniform sagittal crest, the angularly produced occipital crest, the position of the masseteric ridge on the malar bone, and in the points alluded to in connection with the upper and lower carnassials, the species falls into line with the large wolves like *C. occidentalis* and *lupus*,

Text-fig. 74.



- A. Vertical view of upper carnassial of *Canis latrans*.
- B. Vertical view of upper carnassial of *C. antarcticus*.
- C. Internal view of lower carnassial of *C. latrans*.
- D. Internal view of lower carnassial of *C. antarcticus*.

and with *C. pallipes* and *C. lupaster*, which, according to fancy, may be called large jackals or small wolves. These resemblances explain Mivart's dismissal of the cranial and dental characters of *C. latrans* with the remark, "The skull possesses no distinctive characters, nor have we been able to detect any in the shape of the teeth."

On the other hand, the skull of *C. antarcticus*, with its lyriform sagittal area and truncated occipital crest, agrees in the main with the skulls of certain species or subspecies of South-American dogs in the British Museum labelled *C. thous* (= *cancrivorus*), *rudis*, *schlacteri* (= *microtis*), *parvidens*, *urostictus*, *gracilis*, and *fulvipes*. And in the skull of a dog, perhaps referable to *C. gracilis*, which



came from Mar del Plata and died in the Gardens, the above-described crests on the upper carnassial are not better developed than in *C. antarcticus*, and the masseteric ridge on the malar bone shows a decided approximation to the condition seen in that species. This latter character is still better marked in the skull of another South-American dog, the exact locality of which is unknown, but which was a different species\* from the Mar del Plata example, and the crests on the carnassial exhibit the same feebleness of development. But it may be noted that in both these skulls the positions of the cusps on the upper and lower carnassials are more *latrans*-like than *antarcticus*-like, so that in this respect at least they serve to bridge over the difference between those two species; a fact in keeping with the idea that *C. antarcticus* is a specialised form of the group of South-American dogs above alluded to, but specialised in a direction away from that taken by *C. latrans* and its allies.

The external characters of *C. antarcticus* and *C. latrans* also afford no justification for the claim of close relationship between them. In the first place the ears of *C. antarcticus* are very small, smaller indeed comparatively, I believe, than in any wild species of the dog family, with the exception perhaps of *C. solateri*, *C. (Nyctereutes) procyonoides*, and *Vulpes (Alopex) lagopus*. In *C. latrans*, on the contrary, they are as large as in most, at all events, of the species of *Canis*. An idea of their length in the two species may be gathered from the measurement of a specimen of each of approximately the same size given by Mivart, the ear of *C. antarcticus* being 6.5 cm. (= about  $2\frac{1}{2}$  inches) and that of *C. latrans* 14 cm. (= about  $5\frac{1}{2}$  inches), or more than twice as long. It may be added that the measurement of 2 inches 9 lines assigned by Waterhouse to the ear of *C. antarcticus* confirms Mivart's statement.

As regards colour *C. latrans* varies from grey to greyish fawn, mixed with black above, and shows the characteristic clouded or patchy coloration caused by the running together of the bands of the individual long coarse hairs of the back and sides seen in so many of the so-called wolves and jackals. One of these long coarse hairs, pulled at random from a skin, measured about 3 inches long, the black tip being  $\frac{1}{2}$  inch (12 mm.) and the whitish area below it 1 inch (25 mm.). The whole of the ventral surface from the chin to the root of the tail is usually white or whitish, and always apparently markedly paler than the back and sides, though sometimes the continuity of the light tint is interrupted on the throat by an infusion of fawn. There is no dark patch above the hock on the hind leg, and the tail matches the back approximately in colour throughout, the tip and the gland-spot being blacker than the rest.

In *C. antarcticus* the coat is thick and soft, and comparatively short, with none of the long coarse hair seen in *C. latrans*. One

\* The South-American dogs of this group are in such a systematic muddle that it is very difficult to identify specimens without a complete revision of the whole series.

of the longish hairs pulled at random from the back measured only  $1\frac{1}{2}$  inches (37 mm.) in length, the dark apical tip being  $\frac{1}{4}$  inch (6 mm.) and the pale band below it  $\frac{1}{8}$  inch (3 mm.) in length. The prevailing colour of the body is brown, relieved by the fine speckling due to the narrow pale band on the individual hairs just described. The lower side is white only on the posterior portion of the belly and on the upper end of the throat, the chin and lower jaw being white stained with a fuscous tint. Apart from the areas described the ventral surface is brownish. There is, moreover, as Mivart said, a fuscous patch above the hock of the hind leg and the tail is particoloured, its basal portion being like the back, its tip white, and the intermediate area blackish, the colour of this area gradually blending proximally with the brownish basal portion, but being quite black distally and sharply defined from the white terminal area.

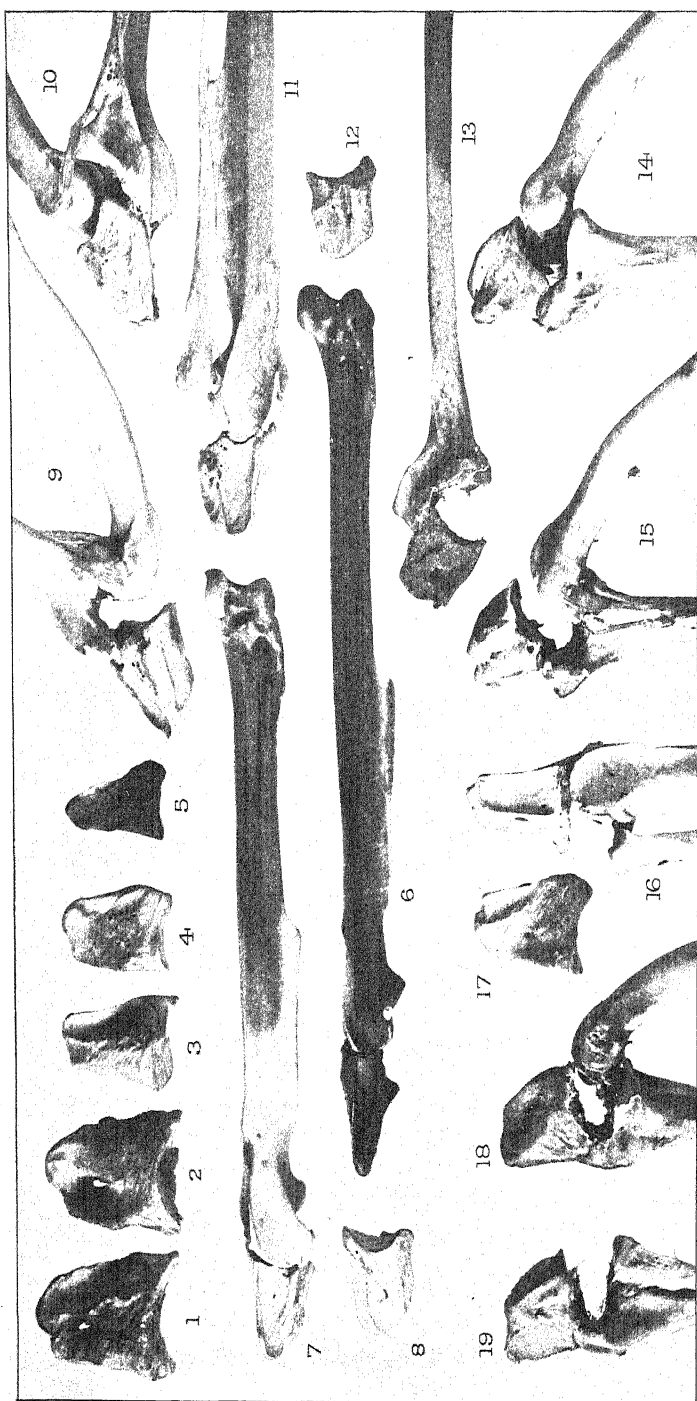
Perhaps it may rightly be claimed that these differences in the length of the ears and in colour do not count for much in themselves. That may be so. Nevertheless, if *C. antarcticus* and *C. latrans* were only known from their skins, it is quite certain that the latter would be placed in the same category with such species as *C. pallipes* and *C. lupaster*, and that *C. antarcticus* would be excluded therefrom. The latter would be difficult to classify; but there is one significant colour-feature connected with the species. This is the presence of the dark patch above the hocks; and the interest of this lies in the circumstance that it is a very common feature in various species of the smaller South-American dogs and occurs in some of the species of *Vulpes*, like *V. chama* \*.

There is one other little point that may be referred to. Darwin says he was informed that the cries of *C. antarcticus* resembled those of the South-American species *C. azarae*. I have never heard *C. azarae* bark or howl, but the keeper in the Gardens informs me that examples of wild dogs from Mar del Plata and Cordova, which are closely allied to and perhaps only racially distinct from *C. azarae*, bark after the manner of foxes. On the whole, however, they are silent dogs in captivity, and, like the foxes, never succumb to the temptation of joining in the howling concerts in which the dingos, jackals, prairie wolves, and large wolves in the Gardens indulge, and which they seem unable to resist contributing to. Personally I believe that voice in mammals is often a good guide to affinity; and, in the present case, the voices of *C. antarcticus* and *C. latrans* bear out my opinion of the relationship of these species to others, shown by structural characters.

Finally, if the conclusions above put forward are correct, Huxley's classification, expressed in par. 5 (p. 384), must be emended by transferring *C. antarcticus* to the lowest section of

\* The presence of this patch in some of the primitive Canidæ is well worth more attention than it has received. I do not know what it may mean, any more than I know what the pale area behind the shoulder, observable in many Canidæ, both wild and domesticated, may mean.





R. W. S. photo.

PATELLÆ OF PHALACROCORACIDÆ.

dogs, containing *C. thous* (= *carnivorus*) and *vetulus*, and by uniting his Sacaline and Lupine sections. Possibly these sections contain groups worthy of subgeneric, if not of generic, recognition: *C. antarcticus* and *C. thous*, for example, may be subgenerically or generically separated by the structure of the mandible; but I do not see how *C. latrans* is to be distinguished other than specifically from such forms as *C. pallipes*, *anthus*, or even *lupus*.

### 30. On the Patella in the Phalacrocoracidae.

By Dr. R. W. SHUFELDT, C.M.Z.S.

[Received April 14, 1913: Read May 20, 1913.]

(Plate LXI.)\*

While recently employed in preparing a detailed account of the skeleton of Harris's flightless Cormorant (*Nannopterum harrisi*), in which the osteology of that species is compared with that of a number of others of the family, I became interested in the morphology of the patellæ of those birds.

Many years ago I published a number of papers † on the skeleton in the Cormorant, in some of which the patella of the Phalacrocoracidae was referred to and figures given of it. But my material, at the time to which I refer, was very limited—in fact I think there were but the skeletons of one or two species of those birds at hand, and this included the skeletons of two or three young ones.

In the higher groups of birds the patella, when present, is usually small, and offers but little of value to the avian taxonomist. This, however, is not the case when we come to examine into the osteology of some of the groups occupying lower positions in the system, and especially is this true of many of the Pygopodine forms and their allies near and remote.

Owen paid but scant attention to this bone of the skeleton in Aves, devoting less than half a paragraph to it, thus:—"The chief of the sesamoid bones in the hind limb is the patella: it is of unusual size in the Penguin, is ossified from two centres, and articulates with the procnemial process of the tibia: it coexists with the long rotular process in the Loon, fig. 34, *l*; it is large and of an angular form in the Musk-duck (*Biziura*): in the Merganser the patella is largest and deeply notched; in the Coot it is elongate. In most aerial birds a patella is wanting" ‡. There is no reference made here either to a Grebe or a Cormorant, and

\* For explanation of the Plate see p. 402.

† Shufeldt, R. W. "Osteology of the Cormorant," Science, Dec. 7, 1883, p. 739; Feb. 8, 1884, vol. iii. No. 53, p. 143; *ibid.* Apr. 18, 1884, No. 63, pp. 474, 475.

"Concerning some of the forms assumed by the Patella in Birds," Proc. U.S. Nat. Mus. 1884, vii. pp. 324-331. Numerous text-figures.

"Osteology of the Steganopodes," Mem. Carnegie Museum, Pittsburgh, Pa., Apr. 1903, vol. i. No. 3, Art. 3, pp. 15-70. Plates and many text-figures.

‡ Owen, Richard. Comp. Anat. and Phys. of Vertebrates, vol. ii. p. 83, London 1866.

Professor Owen evidently considered the small, scale-like bone found in the tendon of the extensor femoris, at its insertion, to be the patella in that bird. When I first examined this question, this was likewise my opinion, and in a paper on the patellæ in birds, published in 1884 in the 'Proceedings of the United States National Museum,' I so figured it (fig. 4, p. 328) for *Colymbus septentrionalis* (*Gavia stellata*). This opinion was to some extent qualified later on, when I stated, with respect to the Loons ("Urinatoridæ") that they possess "only a very small, flake-like sesamoid, which occurs in the tendon of the extensor femoris muscle at its insertion, and probably the true patella has coössified in the adult with the elongated cnemial process of the tibio-tarsus"\*. Possibly some avian osteologist has published on this subject, but if so, I have not seen the work; and never having been so fortunate myself as to have come into possession of the skeleton of any Loon, secured at the right time to demonstrate the exact composition of the tibio-tarsus in that bird, I am still in doubt on the question. However, it is quite possible—indeed quite likely—that the true patella in Loons (*Gavia*) is, in the adult, completely coössified with the great elongate cnemial process of their tibio-tarsi. The moulding of the patella on the back of this process in Grebes, especially in very old birds, is wonderfully close,—so close in some ligamentous preparations as to deceive the eye upon casual examination.

To settle this interesting point—if it has not as yet been settled—will require the examinations of the skeletons of Loons including those of individuals of the genus of all ages.

At present I am inclined to think that the patella in *Gavia*, in the adult, has been indistinguishably fused with the cnemial process of the tibio-tarsus, for the reason that it is on the road to such a fate in the Grebes (Colymbidæ), and that in all such birds as *Hesperornis*—an ancient ancestor of the Loons—the Penguins, the Cormorants, and some others, the patella is very large.

Then, finding it large in a Grebe, one would naturally look for the same in such forms as Loons, especially when one considers the relationship of these two families.

The statements now being made are, in a way, prefatory, leading up to what I have to say on the patella of the Cormorants. It must be borne in mind in this connection that the patella in Penguins is very large, and grooved obliquely across the anterior face for the tendon of the ambiens muscle†.

\* "Concerning the Taxonomy of the North American Pygopodes based upon their Osteology," Jour. Anat. & Phys. London, Jan. 1892, pp. 199-203. The lines quoted are from page 202. In this paper I also give two figures of the skeleton of the thigh and leg of a Grebe, in which the patella is included. One of these figures was reproduced by Coes in his fifth edition of the 'Key,' without acknowledgment (vol. ii, p. 1052, fig. 712).

† Coes, E. "Material for a Monograph of the Spheniscidæ," Proc. Acad. Nat. Sci. Phila. xxiv. 1872.

Watson, Morrison. "Anatomy of the Spheniscidæ" (Rep. Scient. Results of Voyage of H.M.S. 'Challenger,' Zoology, vol. vii, pl. vii, figs. 9 & 10, 1883).

Shufeldt, R. W. 'Proc. U.S. Nat. Mus. 1884, p. 326, fig. 1. Reproduces from Watson figures of patellæ of *Aptenodytes pennantii* and *Eudyptes chrysocome*. Comments

Personally I have not examined the patella in *Hesperornis* with the view of substantiating Marsh's statement that it is "perforated by a large foramen for the tendon of the ambiens muscle, agreeing in this respect with the patella of the Gannet (*Sula bassana* Briss.)." His several figures of the patella of *Hesperornis regalis* do not show this "large foramen" ('Odontornithes,' p. 23, plates xv. and xx. figs. 1-3), while I have yet to see the patella of *Sula bassana* presenting any such perforation for the ambiens muscle as Marsh describes.

However this may be, the fact remains that very radical differences exist with respect to the fate and disposition of the patella and cnemial process of the tibio-tarsus in Grebes, Loons, *Hesperornis*, Penguins, Gannets, Cormorants, and many other different species of water birds. Great differences also exist in the morphology of this sesamoid and the aforesaid apophysis.

This brings us to a point where the patella of the Phalacrocoracidae may be discussed. For this purpose I have before me the skeletons of several species of Cormorants, all belonging to the Collection of the U.S. National Museum, to which institution I am indebted for the loan of them. It will not be necessary to name these species here or to give their museum numbers, as this information is fully set forth in the explanation of Plate LXI., which appears at the end of this article. As to the 19 figures on the plate, they are reproduced, natural size, from my own grouping and photograph,—the latter having been made direct from the specimens.

Among avian osteologists the general opinion has prevailed that the patella in Cormorants is a big trihedral one, in some way "perforated" for the ambiens muscle.

Garrod found the ambiens muscle present in the family Phalacrocoracidae; and, in noting that Meckel had not done so, he states that "it is peculiar in that [in the Cormorant] it runs through the substance of the large triangular patella, in a bony canal" \*.

In another paper this gifted ornithotomist is still more positive, and in speaking of the "Steganopods," he says: "The ambiens is of fair size; it deeply grooves the large ossified patella; and some of the fibrous ligament overlapping this groove shows traces of ossification; so that in aged birds the groove may be converted into a foramen, as is always the case in *Phalacrocorax*, where the

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made thereon. There is a curious slip in this paper with respect to the description of the patella of the Gannet (*Sula bassana*). On page 362 I state that "Professor Marsh tells us that the patella of *Sula* is perforated by a large foramen for the passage of the tendon of the ambiens muscle." On pages 329 and 330 I quote the entire paragraph from Marsh's 'Odontornithes' (p. 93) where he gives this description of the patella of *Sula* and states on page 327 that "I fail to find any such foramen in the patella of the specimen of *Sula* before me, although it has a shallow, oblique groove across its anterior face that seems to correspond with the one described when speaking of the patella of the Penguin." This statement is supported by a correct figure of the patella in *Sula bassana* (No. 16643, Coll. U.S. Nat. Mus.), and I must believe that the description left us by Prof. Marsh is another of those curious slips of his in the osteology of modern birds.

\* Garrod, A. H. "On Certain Muscles of the Thigh of Birds, and on their value in Classification," Pt. I. P. Z. S. 1873, pp. 636, 637 (footnote).

thus formed foramen is far from superficial"\*. This is a very interesting statement, and will be commented upon further on in this paper.

Forbes, in describing the anatomy of *Biziura*, makes the statement that "The ambiens muscle is large, and peculiar in that its tendon *perforates* the large-sized triangular patella, just as it does in *Phalacrocorax* and the extinct *Hesperornis*"†.

When referring to this sesamoid in the Cormorants, Coues says, in the fifth edition of his 'Key' (p. 961), that "There is a bulky, free patella, coexistent with a short cnemial apophysis or rotular process of tibia, but perfectly distinct therefrom, as in Grebes." This somewhat ambiguous description is made clearer by an illustration of the patella in "*Phalacrocorax bicristatus*," which he borrowed from a previous paper of mine. Nothing is said with regard to the ambiens or the "perforation" in the patella, so this note is quite useless for present purposes.

From my own various accounts of the patellæ in Cormorants I select the following as best suited to throw light upon the facts I propose to here set forth.

In my above-cited article on the patellæ in birds (Proc. U.S. Nat. Mus. 1884, p. 330, fig. 7) I remark: "In No. 41 of 'Science,' I presented a lateral view of the leg-bones of a Cormorant (*Phalacrocorax*), showing the form of the patella in these birds. The same specimen is given here, only an anterior view is chosen instead of the lateral one.

"This form is a particularly interesting one, and I am not aware of any bird at present that can show a similar condition of the parts in question.

"On the face of it, it almost looks as if a patella had developed of a size equal to the rotular process, and subsequently the two became thoroughly united, and formed one large patella, articulating as shown in the drawings I have made of it. I do not say that this is actually the case, nor were the young of this specimen, which also belong to the collections at the Smithsonian Institution, of a proper age to determine exactly the manner in which this great bulky patella was developed."

Apart from the suspicion expressed in this last paragraph, which will be put into more exact terms further on, there are but two opinions extant, at present, in regard to the development of the patella in the Phalacrocoracidae. They are the opinions of Garrod and of Forbes, and have been set forth in their own words above.

There is but one construction that can be placed upon Forbes's view of a Cormorant's patella, and that view cannot be successfully defended. It will be noted above that, in his calling

\* Garrod, A. H. "Notes on the Anatomy of *Plotus anhinga*," P. Z. S. 1876, p. 340, pl. xxviii, figs. 5, 6. The figures give the patella, indicating the position of the foramen.

† Forbes, Wm. Alex. "Note on some points in the Anatomy of an Australian Duck (*Biziura lobata*)," P. Z. S. 1882, p. 457.

I regret to say that I have never had the opportunity of examining the patella in this duck, and I doubt if we have a skeleton of it in the United States.



attention to the fact that the tendon of the ambiens muscle passes through the patella in Cormorants, he uses the word "perforates" (emphasizing it by the use of *italics*). Surely he could not have meant that the tendon really did "perforate" or bore its way through the patella as the Cormorant grew and developed? And, after finding its way through the bone (or cartilage) that it duly made attachment at its point of insertion? No such thing has ever occurred in anatomical development, and Forbes was altogether too good an anatomist to have set up any such ridiculous explanation. This being true, and disregarding entirely any such theory or such another possible suggestion as that, in subadult life, the patella of a Cormorant, forming first in elementary cartilage, does, when in that condition, surround the tendon of the ambiens muscle, and afterwards, when the patella has completely ossified in old birds, the aforesaid tendon runs through a foramen, which passes through the middle of it. Barring this, too, as I say, as being a totally untenable suggestion, we are left with but two other possible ways by means of which the ambiens comes to pass through the foraminal canal in the patella of Cormorants.

In discussing these, we are at once confronted with Garrod's opinion in regard to it—an opinion which had never, apparently, occurred to Forbes. Garrod took the view that, inasmuch as in *anhinga* (*Plotus*) the anterior face of the patella is somewhat deeply grooved, and as ligament stretches across that groove to confine the tendon of the ambiens muscle which passes through it, and as this same ligament sometimes "shows traces of ossification,"—hence in Cormorants this also takes place, and the fibrous ligament in them becomes, in old individuals, thoroughly ossified, and we thus find the tendon of the ambiens passing through the bone.

Such an opinion will not hold for an instant in the face of the necessary material to examine into it.

Now in some Cormorants the patella is very large and thick, and the aforesaid foraminal passage, passing through it from side to side, is found but slightly in advance of the middle and above the centre of the bone; so that, had it been a "groove" in the young bird spanned by fibrous ligament, and this ligament subsequently ossified in the adult, that groove must have been a very deep one, and the patella in old birds would, through its form alone, after ossification was complete, exhibit the manner as to how it had come about. Moreover, in connection with this it is very clear that, were the foramen in the patella in Cormorants formed by a groove in front of it being covered over by fibrous ligament in the subadult bird, which ligament later in life ossified, that ossification would be smooth on its anterior face, which is by no means the case, as one may see by a study of the figures in the plate accompanying this paper. For instance, a fibrous ligament, stretching across a deep, narrow groove as a retaining band for the tendon of a muscle, would not, in ossifying, take on any other shape beyond that possessed by the flat ligamentous band; for

instance, as I say, such as has occurred in the patella shown in Pl. LXI. fig. 11 and others. It must stand to reason, then, that Garrod entertained an untenable opinion in this matter.

Coming to the second way in which this foramen could have been formed, it is clear that, in young and subadult individuals, the tendon of the ambiens muscle could be confined by an additional piece of bone or cartilage being placed in front of it, and this added part subsequently ossify and not only form, in the adult, a foraminal passage for the aforesaid muscle or its tendon, but largely add to the bulk of the patella. It might, too, —from the thoroughness of the coössification—cause the atrophy of the muscle and its tendon at that part of the course of the latter across the front of the true patella; and such a result would be brought about by the entire sealing up of the foraminal passage, which not only actually takes place in the patellæ of some Cormorants, but again proves Garrod to have been wrong when he stated that such a foramen or foraminal passage was always present in the patella of Cormorants. See Pl. LXI. fig. 3—*Phalacrocorax penicillatus*—where it has been sealed up entirely, leaving not so much as a trace or a suspicion of its ever having been present there.

In my opinion, the foraminal passage for the ambiens muscle, passing transversely through the patella in the Phalacrocoracidae, when present, is formed as set forth below, which formation can be demonstrated by the material figured in the plate accompanying this paper. When the foraminal passage is entirely absent it has been absorbed, atrophy of the ambiens probably having ensued.

It would appear that in young Cormorants the ambiens passes in a groove, of the required depth only, obliquely across the anterior face of the patella, which latter is very closely adpressed against the posterior surface of the long cnemial process of the tibio-tarsus,—a condition that persists throughout life in Grebes (Colymbidae). Coössification between the patella and the upper two-thirds of the cnemial process of the tibio-tarsus, in the case of the growing Cormorant, next sets in, which, owing to the morphology of the parts involved, would, in time, depreciate the action of the knee-joint. This is clear when we come to consider the origins and insertions of the various muscles about the knee-joint anteriorly, posteriorly, and laterally\*. These, during their continued action in locomotion—especially during the act of swimming—tend to overcome the aforesaid danger, militating against the complete freedom of action of the knee-joint. Coössification steadily proceeds; the individual grows; a constant tugging is exerted during locomotion at the tibio-tarsal cnemial apophysis. This eventually results in its becoming dissociated from the bone to which it belongs along a transverse line, at a short distance above the level summit of the tibio-tarsal shaft, thus leaving the lower third of the cnemial

\* Shufeldt, R. W. 'The Myology of the Raven,' p. 187, figs. 51-53, London 1890.

process where it occurs in all birds when such an apophysis is present\*.

In the *Phalacrocoracidae*, then, the patella is a compound bone, consisting of the true patella posteriorly, and the upper two-thirds, more or less, of the cnemial process of the tibio-tarsus anteriorly, which latter has become dissociated and thoroughly coössified with the former. By this union, a foraminal passage is formed for the ambiens muscle, and this, in some species, may gradually, but entirely, disappear, whereupon, in time, the muscle meets its usual fate.

For very obvious reasons, the patella is very large in Harris's flightless Cormorant (*Nannopterum harrisi*); indeed, in so far as I have been enabled to discover, it is larger in this species than in any other existing form of the entire family (Pl. LXI. figs. 1 & 2). It has an average height of 25 millimetres, the longest diameter of its base being 19 or 20 millimetres, and is nearly a square in outline. Posteriorly, it is flat and triangular, the acute angle being above. Above its middle, and nearer its posterior surface than its anterior margin, it is pierced, transversely, by the foramen for the ambiens, which is of considerable size. Externally, its exit is almost flush with the surface of the bone, while on the inner aspect it is situated at the base of an extensive concavity. Anteriorly, this compound bone exhibits a uniform longitudinal excavation which, when the patella is articulated as in life, is the continuation with the similar excavation between the pro- and ectocnemial processes of the tibio-tarsus. On the anterior face of this patella, at the lower-internal angle, there is a transverse, triangular facet which is intended for articulation with the superior border of the cnemial crest of the tibio-tarsus. In fig. 2 we have the mesial or inner aspect of the *left* patella of *N. harrisi*, from the same skeleton (No. 19719), where the perforating foramen for the ambiens is seen at the base of the aforesaid extensive concavity. A study of these two patellæ reveals the nature of the composition of the bone as a whole, as described above.

*Phalacrocorax penicillatus* possesses only a medium-sized patella, which is elongate and wedge-shaped. It has the general form of the patella in *Nannopterum*: but the transverse foraminal passage for the ambiens has been entirely absorbed,—not a vestige of it remaining in an individual of the age to which this patella belonged. The union of the two parts composing the bone is very complete, and all traces of their origin have been entirely obliterated,—that is, beyond the anterior rotular channel, and the here extensive facet below it for articulation with the cnemial process of the tibio-tarsus.

This is a most excellent example of the patella in a Cormorant

\* This is the part referred to by Coues in his 'Key' (5th ed. vol. ii. p. 961), where he describes the patella in the *Phalacrocoracidae* in the following words: "There is a bulky free patella, coexistent with a short cnemial apophysis or rotular process of tibia, but perfectly distinct therefrom, as in Grebes." It is very evident from this definition that Coues had never given the patella of a Cormorant any very close study.

showing the conditions described as they occur in a very old bird (figs. 3 & 4), and they are equally well shown in the patella of *P. punctatus* (figs. 5 & 6), where the foraminal passage has likewise entirely disappeared. The rotular channel in front is very narrow and pointed above, as in a Grebe or Loon, and there is a rounded notch on the superior border of the cnemial process of the tibio-tarsus, which marks the limitation, externally, of the facet for articulation with the patella on that border (fig. 6, where this "notch" is plainly seen). This patella gives barely any hint as to the two parts of which it is composed.

This is to a less degree true of the patella of *Phalacrocorax magellanicus* (figs. 7 & 8); for here again we find the foraminal passage in its very last stages of ultimate absorption, while the continuation of the rotular channel on the anterior face of the patella, and the evidence of this part of the patella once having belonged to the tibio-tarsus, is very complete (fig. 7, which should be compared with fig. 6, the former in no way recalling the form of these bones in the Grebe).

*Phalacrocorax urile* (Nos. 19655 & 18982) has, in old individuals, a rather bulky patella (figs. 9, 10, & 11), in which, in the specimens selected, the foraminal passage is reduced to capillary proportions, and the sutural traces of the elements composing it have become nearly obliterated. Fig. 10, which is from the right limb of *P. urile*, No. 18982 of the Collection of the U.S. National Museum, shows the minute entrance to the foraminal passage; while in fig. 11, it being the left limb from the same skeleton, the opposite opening is in view,—posterior to two other foramina which occur here. Fig. 11 is given on the plate, to the exclusion of the patella of *Phalacrocorax carbo*, for the reason that in no Cormorant, other than *P. urile*, do we find, on this anterior view, a better example of the intercnemial channel on both the big sesamoid and the tibio-tarsus, and the line between them where they eventually parted company.

*Phalacrocorax carbo* (No. 18850, Coll. U.S. Nat. Mus., not figured) has a patella that is an interesting one in several particulars. On its inner aspect the surface is flat and smooth, the minute opening of the almost entirely absorbed foraminal canal being situated far posteriorly upon it. In size and general form the patella of this Cormorant is much like the one shown in figs. 18 & 19 of *P. pelagicus*; while it likewise possesses characters peculiarly its own. It has the usual trihedral form, and makes rather more than the average articulation with the tibio-tarsus in extent, especially on the proximal margin of the procnemial process. Its posterior face is triangular and flat, while the external one is pierced near its middle by the outer opening of the foraminal passage. Anteriorly, the usual intercnemial channel is present, it being continuous with the same on the tibio-tarsus. On the patella it is unusually narrow, and faces very much to the outer side.

*Phalacrocorax carbo* (No. 18851) has the patella almost exactly like that in *P. urile* (figs. 10 & 11.) The former,

however, in this particular individual, has completely lost the foraminal passage, while otherwise the morphology is quite the same.

One of the most interesting forms of the patella among Cormorants is found in *Phalacrocorax vigua* (figs. 12 & 13); for it is not only very small and chunky, but the facet on its infero-anterior aspect for the tibio-tarsus is relatively, as well as actually, large. On the inner aspect, the big foraminal opening is situated at the base of a fossa, as in *Nannopterum harrisi*, while on the external side it is small again, and has, leading down from it to the lower border of the bone, a deep groove, which not only indicates the suture between the two elements composing this bone, but apparently the continuation of the groove for the ambiens as well.

Passing to *Phalacrocorax auritus* (No. 19262), the patella of which species is shown upon two views in figs. 14 & 15, we find that that sesamoid is rather small for a Cormorant of its size. In it, the foraminal passage has gone entirely, while the bone, upon the other hand, shows better than any other Cormorant's patella I have examined, the two parts of which it is composed. These are very plainly to be seen in the figures,—indeed, equally as well as in the specimens themselves.

There is a large patella in *Phalacrocorax albiventris* (No. 18437, figs. 16 & 17), where again we find, in the adult bird, the foraminal passage almost obliterated, having been reduced to a capillary calibre throughout. Sutural traces between the bone are faint, while anteriorly the rotular excavation is broad and deep, being but slightly wider at the top than it is at the distal border.

A most instructive patella is found in *Phalacrocorax pelagicus* (No. 19032, figs. 18 & 19). Once more we find the foraminal passage reduced to a very small calibre, though the entrances on the inner and outer surfaces of the bone are still in evidence, though very small. What is to be specially noted among other things is, however, the position of the foraminal aperture on the inner aspect (fig. 18); this is but 4 millimetres from the posterior margin of the patella, while it is 9 millimetres from the anterior margin, which is sufficient to render the theory of the "anterior" groove being filled in by an ossified fibrous ligament—ridiculous.

In its amalgamation and coössification of its parts, this patella became to a large degree twisted,—a twisting that cannot well be appreciated in the figures. Still, the bone fits most accurately on the superior border of the cnemial process of the tibio-tarsus,—its lower border, antero-posteriorly, being no thicker than is that of the leg-bone, while everything in its morphology plainly indicates its origin. On the front of the patella, the rotular channel is somewhat shallower than usual, and is as broad above as it is below, where it, in all particulars, directly continues the corresponding channel separating the pro- and ectocnemial apophyses of the tibio-tarsus.

The obliquity of the foraminal passage for the ambiens is easily made out, its higher aperture being on the inner aspect of the bone, and situated, as I have pointed out above, far back from the antero-internal border of the bone. To best appreciate the fact that this sesamoid in *P. pelagicus* is formed as I have demonstrated it to be in Cormorants of all species, it should be viewed from above rather than from either side or in front.

#### EXPLANATION OF PLATE LXI.

[All the figures are reproductions of photographs made by the author direct from the specimens. Each bone is of natural size, and from an adult individual. They are from skeletons in the Collections of the U.S. National Museum, the Museum numbers of which are given under the figures.]

- Fig. 1. Right patella of *Nannopterum harrisi*; antero-lateral aspect. (No. 19719.)
2. Left patella of *N. harrisi*; mesial or inner aspect. (No. 19719.)
3. Right patella of *Phalacrocorax penicillatus*, antero-lateral aspect, or the same view in which fig. 1 is shown. (No. 18535.) Note that the foraminal passage for the ambiens has been entirely absorbed.
4. Left patella of *P. penicillatus*; inner aspect. (No. 18535.)
5. Left patella of *Phalacrocorax punctatus*; inner aspect. (No. 18282.)
6. Left tibio-tarsus of *P. punctatus*; anterior view, with the patella articulated *in situ*. (No. 18282.)
7. Right tibio-tarsus, anterior view, of *Phalacrocorax magellanicus*, with patella articulated *in situ*. (No. 18438.)
8. Left patella of *P. magellanicus*; inner surface. (No. 18438.) Note that the exit of the foraminal passage points to the fact that it is in the very last stages of its ultimate disappearance. This is an interesting link in the chain of evidence on the real composition of this bone in the *Phalacrocoracidae*.
9. Proximal extremity of tibio-tarsus and fibula of right pelvic limb of *Phalacrocorax urile*; adult. (No. 19655.) Outer aspect, with patella and femur articulated *in situ*.
10. Inner aspect of the bones composing the knee-joint of *P. urile*; partly ligamentous. (No. 18982.) Right pelvic limb.
11. Left patella, tibio-tarsus and fibula (superior moieties), anterior aspect; left pelvic limb of *P. urile*. (No. 18982.) Note the complete union and the continuation of the rotular channel of the tibio-tarsus on the anterior face of the patella.
12. Right patella of *Phalacrocorax vigua*; outer surface. (No. 18479.) Note groove leading down from the foraminal opening.
13. Left tibio-tarsus of *P. vigua* (No. 18479), with patella articulating *in situ*.
14. Bones of the knee-joint of *Phalacrocorax auritus* ("*P. dilophus*," No. 19262.) Right pelvic limb, inner aspect. Femur somewhat displaced, but patella properly articulated.
15. Bones of the knee-joint of *P. auritus* (No. 19262); left pelvic limb, outer aspect and articulated *in situ*. Note the line of demarcation between the true patella and the anterior part of the bone, which originally belonged to the tibio-tarsus.
16. Anterior aspect of the proximal extremities of the left tibio-tarsus and fibula of *Phalacrocorax albiventris*, with the patella duly articulated above them. (No. 18437.) The rotular channel is very broad in this species and rounded above.
17. Right patella, inner surface of *P. albiventris*. (No. 18437.) The foramen is almost closed up.
18. Bones entering the knee-joint of *Phalacrocorax pelagicus*, adult, nat. size. Right pelvic limb, outer aspect. Ligamentous preparation with femur slightly luxated. Patella *in situ*. (No. 19032.)
19. Skeleton of the knee-joint of *P. pelagicus*. (No. 19032.) Left limb, outer aspect; patella *in situ*.

31. Experiments on the Metamorphosis of the Mexican Axolotl (*Amblystoma tigrinum*), conducted in the Society's Gardens. By E. G. BOULENGER, F.Z.S., Curator of Reptiles.

[Received and Read May 20, 1913.]

(Text-figures 75 & 76.)

During the past year I have been experimenting on points relating to the metamorphosis of the Mexican Axolotl (*Amblystoma tigrinum*), and have succeeded in obtaining the transformation of a number of specimens. This paper deals with the methods employed, and gives a detailed account of the external changes undergone by the animal during the process, a subject which, with the exception of Duméril's (1) brief account, has not, so far as I am aware, been previously treated.

Before describing my experiments, it may not be out of place to give a short account of the history of the animal. Although suspected by Cuvier to be but the larva of some unknown air-breathing salamander or newt, the Axolotl of Mexico was considered for many years to be one of the Perennibranchiata, such as *Proteus*, *Necturus*, and *Siren*. In the year 1863 a number of specimens were imported from Mexico to France, where some, kept in the Jardin des Plantes in Paris, bred, and the young were successfully reared. The conclusion was not unnaturally drawn, that the Axolotl, having bred in the branchiate condition, could not possibly be anything but a perfect aquatic animal. It was, not, however, until over two years later that the subject assumed a different aspect, for some individuals of the second generation lost their gills and the dermal folds of the back and tail, developed eyelids, and yellow spots on the skin, and taking to land, changed into a land salamander, already well known from North America as *Amblystoma tigrinum*.

A few years later Weismann (2) tried to solve the question as to whether it were possible to force the larvæ, if brought into conditions which rendered the use of the gills difficult and that of the lungs easy, to change into Amblystomes, and he therefore experimented with several broods which were placed in shallow water, and thus compelled to breathe air more frequently. Although he met with no success Weismann was not discouraged, and came to the conclusion that the failure of his experiments was due to his having been unable to bestow the necessary care and attention on the animals: he therefore asked Mlle. de Chauvin, a lady who had already done much careful experimental work, to take a number of larvæ, just out of the egg, rear them, and make an attempt to bring them to the perfect condition. When the Axolotls were about 6 months old, Mlle. de Chauvin placed

them in large glass vessels which were so disposed and the water so restricted that at one spot only could they dive quite under, while everywhere else they came into contact with the air. The water was then gradually reduced. Within a few days a change took place, the creatures leaving the water in from four to fourteen days, the complete metamorphosis following about ten days later. Mlle. de Chauvin (3) summarized her results as follows:—"From what I have said, the correctness of the view suggested by Weismann must be established, namely that most Axolotl larvæ, if not all, complete their metamorphosis, if in the first place they come out of the egg healthy and are properly fed, and in the second place meet with arrangements which force them to change from breathing under water to breathing above water."

Dr. J. H. Powers (4) at Doane College, Nebraska, has more recently conducted numerous experiments on the metamorphosis of North American examples of the Axolotl, and he has come to the conclusion that the metamorphosis is not due, as was thought by Mlle. de Chauvin, to a direct response to changes in conditions of environment, compelling them to resort to aerial respiration, but to checked nutrition, and that a careful study of Mlle. de Chauvin's methods and results seems to cast a doubt upon the conclusion that enforced air-breathing caused the metamorphosis. The following is a passage from Dr. Powers's paper on the subject of this lady's experiments:—"Fearing that her charges would die, as indeed they sometimes did, she always prepared them for the trying ordeal of metamorphosis by raising the temperature of the water in which they were kept and feeding to the maximum for several days, to which she ascribes no other importance than giving the animals increased strength. The Axolotls were then brought immediately into water sufficiently shallow as to force them, at least part of the time, to breathe air. In this latter condition the experimenter complains again and again that it was next to impossible to induce the Axolotls to take any food whatever. Thus in these experiments we have high feeding followed by practical starvation, and it seems that no control experiments were instituted to determine what the effects of over and under nutrition might have been with Axolotls still in abundance of water. Yet most interesting is it to note that even the varying factors of nutrition seem to have been wholly neglected in the final interpretation of the results."

Dr. Powers's field-notes show that metamorphosis occurs rarely, if ever, as the result of enforced air-breathing through the drying up of ponds, and that in spite of repeated search at appropriate times and places, no Axolotls have been found transforming on the mud of drying ponds.

Dr. Gadow (5), who not long ago visited the lakes near Mexico City in which this creature lives, and where it is said to retain its branchiate condition, has been able to refute the theories framed



by various zoologists, as to why the Axolotl does not transform in those localities. The reason he gives is that the unfailing abundance of food and water, and the innumerable hiding-places amongst the reeds under the banks, constitute for these Batrachians a real paradise where they remain, in spite of the fact that there is nothing to prevent them from leaving the water. Dr. Gadow's explanation appears to be in keeping with the results of both Mlle. de Chauvin's and Dr. Powers's experiments.

The conflicting conclusions arrived at made it highly desirable that further experiments should be undertaken. The lack of success obtained by the majority of those who have attempted to force the Axolotl to transform, has led many zoologists to believe that the change is due to some congenital disposition, possessed only by certain individuals, and that Mlle. de Chauvin and the few others who have succeeded in obtaining Amblystomes from the larval form were specially fortunate in the choice of their subjects. Therefore, when I commenced my experiments, I was by no means sanguine of attaining any definite results.

In August of last year I obtained five Axolotls with very fully developed gills and fins, ranging in length from 105 mm. to 138 mm., and therefore probably from six to nine months old.

The enforced breathing of air, by the gradual absorption of the water, and by the gradual elimination of the necessary amount of oxygen from the water, starvation and irregular feeding, and increased temperature having all been given or suggested as means of obtaining the metamorphosis, I placed the animals under the following conditions:—

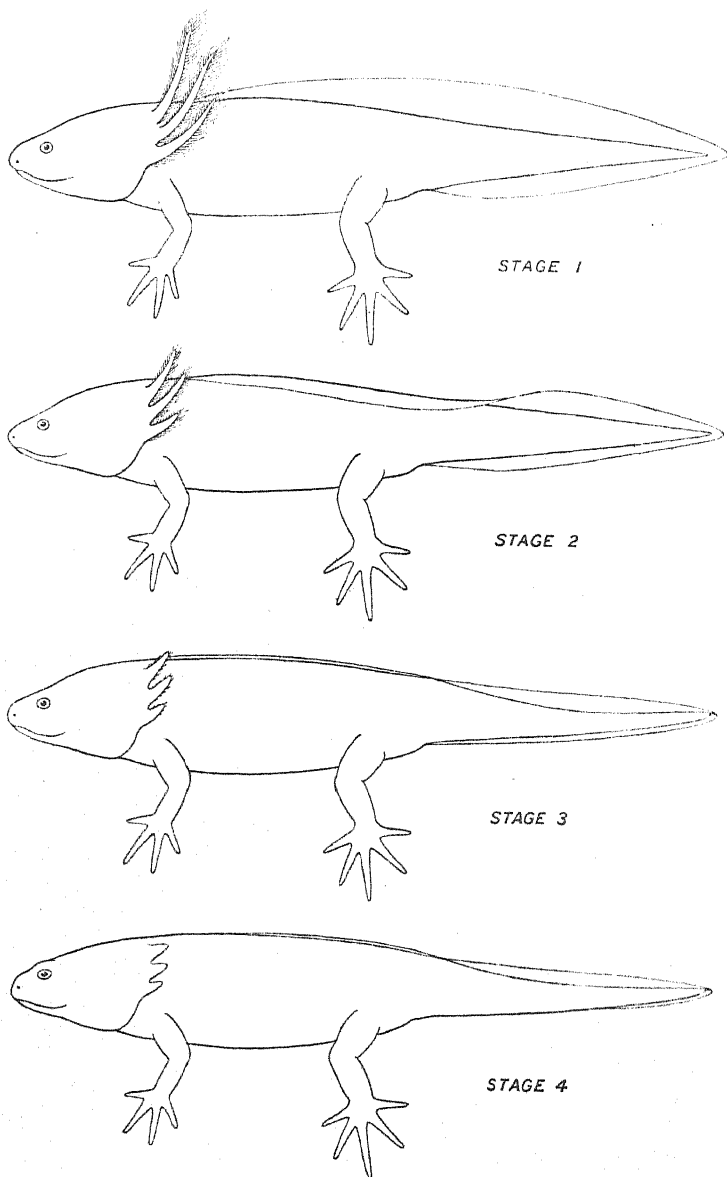
Nos. 1 & 2.—In shallow water so that after the first week only the top of the animal's head and fins remained uncovered, thus forcing the creature to make free use of its lungs. These I kept at a uniform temperature of between 75° and 80°.

Nos. 3 & 4.—Under similar conditions, but at a uniform temperature of between 55° and 60°.

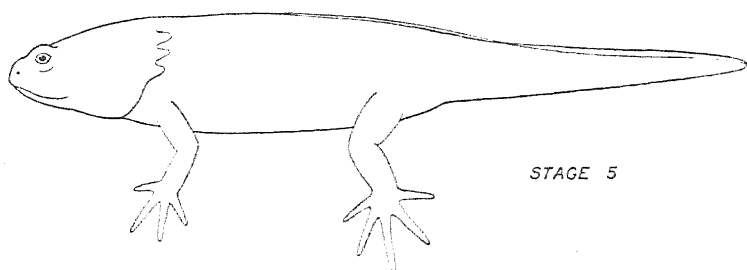
No. 5.—In deep water from which the necessary amount of oxygen was eliminated by the gradual substitution of boiled water and by the introduction of decomposing vegetable matter.

As at the time I could not obtain any more Axolotls of the size required, I decided to abstain from experimenting with the feeding, until I had either obtained negative results with those I was about to experiment on or had secured more suitable specimens. Nearly a month later I was fortunate enough to obtain six further suitable specimens. At the same time some of the first brood showed signs of metamorphosing in spite of the fact that they had fed with the greatest regularity. I therefore decided not to abstain from offering them food as success seemed likely without resorting to starvation, and placed the individuals of the second brood, which shall be referred to as numbers 6, 7, 8, 9,

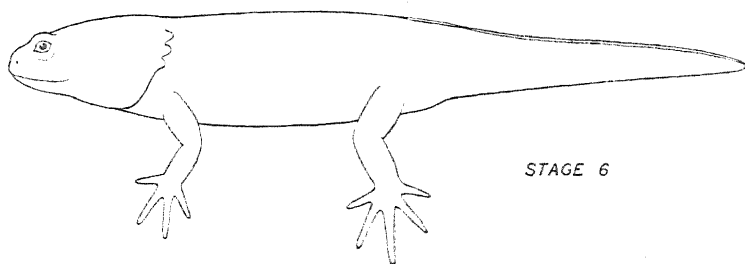
Text-fig. 75.

First stages in the metamorphosis of *Amblystoma tigrinum*.

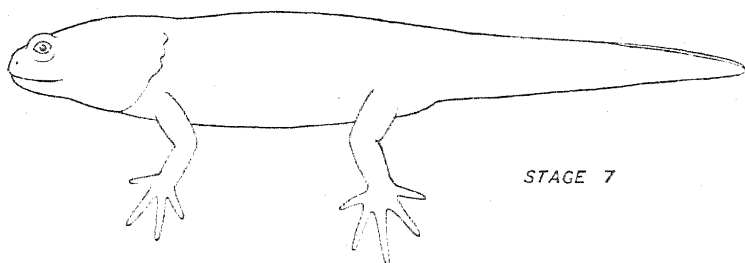
Text-fig. 76.



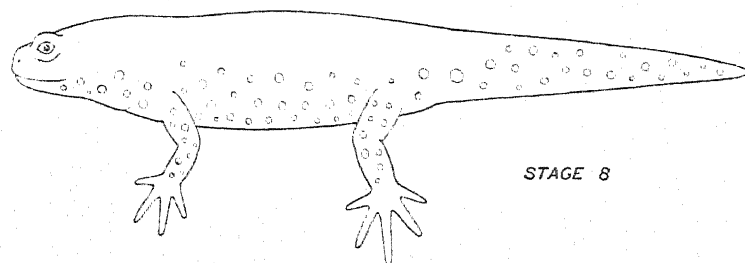
STAGE 5



STAGE 6



STAGE 7



STAGE 8

Final stages in the metamorphosis of *Amblystoma tigrinum*.

10, and 11, under similar conditions to those of brood 1. Nos. 6 and 7 were forced to breathe air, being placed in shallow water, at a high temperature; Nos. 8, 9, and 10 were placed under the same conditions at a normal temperature, and No. 11 was placed along with No. 5 in foul water, from which the oxygen was removed by the addition of boiled water. In all, therefore, I had eleven specimens under artificial conditions with the object of forcing the metamorphosis, and as a result succeeded in bringing six individuals to transform into the Amblystome stage, all six specimens being those induced to make free use of their lungs by being placed in shallow water; three of these were kept at a temperature of between  $75^{\circ}$  and  $80^{\circ}$ , three at between  $55^{\circ}$  and  $60^{\circ}$ . The time required for the entire metamorphosis was from 12 to 16 weeks, periods which all to a remarkable degree exceeded those taken by Mlle. de Chauvin's specimens. Three individuals kept under identical conditions died in from  $3\frac{1}{2}$  months to over 5 months, but not until after having undergone a change, which, although considerable, did not necessarily suggest, as will be referred to later, that, but for their death, the entire metamorphosis would have taken place. The two specimens kept in deep water from which the oxygen was eliminated died in the one case after 19 weeks, in the other after 22 weeks. These specimens, but for a slight reduction in the size of their gills, did not undergo any change, the fins being at the time of their death as well developed as at the commencement of the experiment. It is worthy of note that these specimens, in spite of the fact that they must have felt exceedingly uncomfortable, did not rise to the surface for air, even just prior to their death, more frequently than individuals kept in oxygenated water. Another point of interest lies in the fact that both specimens grew rapidly during this period, No. 5 from 136 mm. to 155 mm., No. 11 from 112 mm. to 120 mm. The specimens kept in shallow water, in the case of those that died, remained stationary, while those that transformed actually decreased in size.

Text-figures 75 and 76 (pp. 406 and 407) represent eight stages through which my Axolotls passed in the course of their metamorphosis.

Stage 1 represents the perfect larval form, the condition which all eleven were in before being placed in shallow water. A few days after the animals had been placed in shallow water, the gills with their fringes began to shrink, and the dorso-caudal fin which lopped over to one side, to the left side in all my specimens, became reduced in size, the change being plainly visible in from a fortnight to three weeks (Stage 2).

In from 10 to 20 days later the gills were only half their normal size, while the fin of the back was represented by a mere ridge; that of the tail, although having undergone further reduction, was still well developed on the upper surface and flopped over to one side; on the lower surface, however, it showed considerable reduction (Stage 3). It was not, however, until from five to seven weeks later (Stage 4) that the metamorphosis proper

took place, when the part of the dorsal fin nearest to the head began to be entirely absorbed; at the same time the head became shorter, assuming a more Salamander-like shape, while a swelling above the eye foreshadowed the advent of the upper eyelid; the gills at this stage measured but from 3 to 5 mm.; the fin of the upper edge of the tail, although now much reduced, still lopped over to one side; the lower fin, but for a rudiment at the extreme end, had entirely disappeared.

Stage 5 represents the conditions seven to eight days later, when the dorsal fin had retreated to the middle of the back; the caudal fin on the lower surface had entirely disappeared; the head had quite altered in aspect, having become much shorter, giving the eyes the impression of having been shifted forwards. At this stage the upper eyelid had become completely formed, the lower eyelid being incomplete.

In from seven to nine days later (Stage 6), the fin of the back had receded to a level with the hind limbs, while on the upper surface of the tail, where it still lopped over, it measured only 1 mm. Both eyelids were now formed. At this stage the animals raised their heads completely out of the water, and the opportunities they were given of getting on land were taken advantage of. Stage 7 represents the creatures about a week later, when nothing remained of the fin but a mere rudiment bordering the extreme end of the upper surface of the tail. The gills were represented by three knobs. Stage 8, the perfect form, the gill slits having closed up and the tail having become more or less roundish, was attained five to eight days later. In the case of both Duméril's and Mlle. de Chauvin's specimens the yellow spots appeared several days prior to the complete metamorphosis; in all my specimens, however, it was not until after they had attained the perfect *Amblystome* condition that the yellow spots put in an appearance, these being situated on the sides of the body, tail, limbs, and throat; none appeared on the back.

As I was desirous of ascertaining whether the metamorphosis could be checked and the shrinking gills and fins made to undergo fresh development, and if so, at what stage it could no longer be checked, two specimens were taken out of the shallow water and replaced in deep water as they reached successive stages in their development. No. 6 was kept at a temperature of between 75° and 80°, and No. 9 at a temperature of between 55° and 60°. Both these Axolotls were placed in shallow water and then induced to breathe air frequently by means of their lungs on October 7th. Stage 2 was reached on October 20th; they were then replaced in deep water. The gills grew immediately and the fins developed, Stage 1 being reached again on October 28th and November 5th. They were then once more put into shallow vessels, with the result that the gills and fins again began to shrink, Stage 2 being attained on November 15th and 20th, Stage 3 on December 5th and 26th. On the latter dates they were again transferred to deep water, Stage 2 being attained on December 20th and January 10th. The metamorphosis was continued on placing the

Axolotls in shallow water, Stage 3 being reached on January 10th and 25th, and Stage 4, the stage when the front part of the fin becomes totally absorbed, on February 12th and 28th. The Axolotls were then returned to deep water: the development at this stage, however, could no longer be checked and both creatures completed their metamorphosis in the water.

From the latter experiment, showing that when replaced in deep water the previous stages were resumed in about half the time required to reach them, the conclusion may I think be drawn that the natural tendency undoubtedly is for the animal to remain an Axolotl, and that compulsion is needed to bring about metamorphosis.

It will be noted that at Stage 4, when the front part of the fin becomes absorbed, the metamorphosis can no longer be checked, and that this is therefore to be regarded as the critical stage, at which the further development must proceed whatever the conditions under which the animal is placed.

During the course of all my experiments, with the exception of the last stages of the metamorphosis, the Axolotls fed with regularity twice a week, and in this respect I experienced none of Mlle. de Chauvin's difficulties.

Below will be found detailed accounts of the conditions under which my eleven specimens were kept, and of the changes which took place under the circumstances.

*Specimen No. 1.*

Placed in shallow water at a temperature of 75°-80°.

- Stage 1. August 17th.—Length 138 mm.
- „ 2. September 1st.
- „ 3. September 15th.
- „ 4. October 17th.
- „ 5. October 24th.
- „ 6. November 2nd.
- „ 7. November 8th.
- „ 8. November 14th.—Length 131 mm.

Total length of period—12 weeks.

*Specimen No. 2.*

Placed in shallow water at a temperature of 75°-80°.

- Stage 1. August 17th.—Length 119 mm.
- „ 2. September 1st.
- „ 3. September 15th.
- „ 4. November 9th.
- „ 5. November 16th.
- „ 6. November 21st.
- „ 7. November 29th.
- „ 8. December 4th.—Length 113 mm.

Total length of period—15 weeks

*Specimen No. 3.*

Placed in shallow water at a temperature of 55°-60°.

- Stage 1. August 17th.—Length 124 mm.  
„ 2. September 25th.  
„ 3. October 10th.  
„ 4. November 12th.  
„ 5. November 20th.  
„ 6. November 27th.  
„ 7. December 5th.  
„ 8. December 11th.—Length 118 mm.  
Total length of period—16 weeks.

*Specimen No. 4.*

Placed in shallow water at a temperature of 55°-60°.

- Stage 1. August 17th.—Length 105 mm.  
„ 2. September 25th.  
„ 3. October 10th.  
Died January 22nd.—Length 105 mm.

*Specimen No. 5.*

Placed in foul water from which the oxygen was removed by the gradual addition of boiled water.

- Stage 1. August 17th.—Length 136 mm.  
Died January 4th.—Length 155 mm.

*Specimen No. 6.*

Placed in shallow water at a temperature of 75°-80°, and replaced in deep water as each successive stage was reached.

- Stage 1. October 7th.—Length 134 mm.  
„ 2. October 20th.

*Replaced in deep water.*

- „ 1. October 28th.

*Replaced in shallow water.*

- „ 2. November 15th.  
„ 3. December 5th.

*Replaced in deep water.*

- „ 2. December 20th.

*Replaced in shallow water.*

- „ 3. January 10th.  
„ 4. February 12th.

*Replaced in deep water.*

- Stage 5. February 18th.  
,, 6. February 25th.  
,, 7. March 3rd.  
,, 8. March 10th.—Length 129 mm.

*Specimen No. 7.*

Placed in shallow water at a temperature of 75°–80°.

- Stage 1. October 7th.—Length 98 mm.  
,, 2. October 31st.  
,, 3. November 25th.

Died January 29th.—Length 98 mm.

*Specimen No. 8.*

Placed in shallow water at a temperature of 55°–60°.

- Stage 1. October 7th.—Length 96 mm.  
,, 2. October 20th.  
,, 3. November 10th.  
,, 4. January 3rd.  
,, 5. January 10th.  
,, 6. January 19th.  
,, 7. January 27th.  
,, 8. February 4th.—Length 91 mm.

Total length of period—16½ weeks.

*Specimen No. 9.*

Placed in shallow water at a temperature of 55°–60°, and replaced in deep water as each successive stage was reached.

- Stage 1. October 7th.—Length 117 mm.  
,, 2. October 25th.

*Replaced in deep water.*

- ,, 1. November 5th.

*Replaced in shallow water.*

- ,, 2. November 20th.  
,, 3. December 26th.

*Replaced in deep water.*

- ,, 2. January 10th.

*Replaced in shallow water.*

- ,, 3. January 25th.  
,, 4. February 28th.



*Replaced in deep water.*

- Stage 5. March 6th.  
,, 6. March 13th.  
,, 7. March 19th.  
,, 8. March 27th.—Length 113 mm.

*Specimen No. 10.*

Placed in shallow water at a temperature of 55°-60°.

- Stage 1. October 7th.—Length 105 mm.  
,, 2. October 31st.  
,, 3. November 30th.  
Died March 24th.—Length 105 mm.

*Specimen No. 11.*

Placed in foul water from which the oxygen was removed by the gradual addition of boiled water.

- Stage 1. October 7th.—Length 112 mm.  
Died March 22nd. ,, 120 mm.

The results of these experiments show, I think, in the first place that, in accordance with Mlle. de Chauvin's observations, and contrary to those of Dr. Powers, the Mexican Axolotl will, with perhaps a few exceptions, transform into the Amblystome stage if placed, when about six months old, under conditions which force it to make frequent use of its lungs; secondly, that starvation, irregular feeding, and temperature have no influence on the metamorphosis; thirdly that, as no change occurs when the Axolotl is placed in poorly oxygenated water, owing to the fact that it will not under the circumstances rise to the surface and make use of its lungs, the quantity of oxygen in the lakes of Mexico can have little bearing on the explanation of the phenomenon of neoteny; and lastly, that there is a critical stage in the metamorphosis.

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32. Contributions to the Anatomy of the Ophidia.  
By JOSEPH C. THOMPSON, Surgeon, United States Navy\*.

[Received April 25, 1913; Read June 3, 1913.]

(Text-figures 77 & 78.)

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*Suggestion as to the Possible Origin of the so-called  
Tracheal Lung.*

It is suggested that the tracheal membrane has been developed as a device originally contributing to the required flexibility of the tube. The cartilaginous rings being interrupted behind, or on one side, permit that the structure be subject to a much greater pressure, especially when bulky morsels are being swallowed, than would be the case were the rings complete. The tracheal membrane, being continuous with the lung, appears to have afforded a convenient foundation for the extension of pulmonary tissue when the need for an increased breathing surface has arisen, or when the lung has been encroached upon by other organs.

In the Hydrophidæ an increased pulmonary area is required both to give buoyancy and to enable the sea-snakes to remain some time beneath the surface. The most specialized species in the genus *Hydrophis* Daudin, those in the *fasciatus* group, possess a lung that extends nearly to the vent, and a tracheal lung of due proportion.

In the Acrochordinæ, the members of which are of aquatic habits, there is also a highly developed tracheal lung. Owing to the abnormal size of the heart the respiratory tissue on the trachea is widely separated from the lung itself.

In the Viperidæ the elaboration of venom requires a large liver. These serpents as a rule have short and thick bodies, and the liver invades the region just caudad of the heart. As a

\* Communicated by Dr. F. E. BEDDARD, M.A., F.R.S., F.Z.S.

result of this the crowded pulmonary tissue seeks the direction of least resistance, which is along the tracheal membrane.

In recording the position of the viscera it has been found advantageous to adopt the following routine with the view of correlating the data obtained. The serial number of the gastrostegæ that underlies the anterior tip or the posterior extremity of an organ is taken as the external landmark. This number is reduced to a percentage, the total number of the ventral shields in the specimen being used as the base. From this procedure there results a set of figures which will materially aid in comparing one species with another or in learning the extent of the variation which the individuals of a given form exhibit.

It appears that whenever a serpent varies widely in an important character from one of the natural groups, a further investigation regularly results in the finding of several additional structural features that are well worth making a matter of record. The single species constituting the family of Xenopeltidae may be taken as an illustration of this general statement.

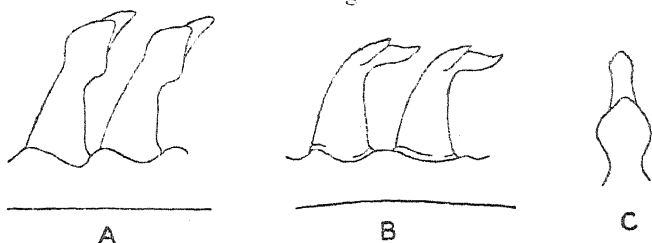
*Some Notes upon Anatomy.*

XENOPELTIS UNICOLOR Reinhardt. (Text-figs. 77 & 78.)

*Specimen.* No. 16750, California Acad. Sci. Singapore. Female; total length 480, tail 58 mm.

*Squamation.*—Scales in 15 rows anteriorly, and the same posteriorly, an oblique series commencing at one gastrostegæ

Text-fig. 77.



Teeth of *Xenopeltis unicolor*.

- A. Maxillary bone viewed at a right angle to the outer edge, and showing the oblique fashion in which each tooth is set in the jaw.
- B. Profile view of the same teeth, showing the lateral cutting-edges of the cusp.
- C. Palatine tooth viewed from below, and showing a stout and blunt tip which exhibits a tendency to assume the arrow-head shape of the cusps.

terminates at the ninth ventral shield to the rear. Gastrosteges 177. Anal divided. Urosteges 32 pairs, the second entire. Loreal and præocular absent. Postoculars 2. Anterior temporals 2, posterior 3. Supralabials 8, the fourth and fifth entering the eye. Infralabials 9.

*Anatomy.*—There are two dental characters in this species that are unparalleled among the Ophidia. The most striking is the shape of the individual tooth, and the fact that the teeth borne on the palatine bone are decidedly the largest. Each tooth is set in the alveolar ridge with the anterior surface directed forward and outward at an angle of  $45^{\circ}$  with the long axis of the bone. When a tooth is viewed from the anterior surface, it appears a trifle constricted at the middle; towards the extremity it flares out laterally, and terminates like a blunt spear-head, with two cutting-edges that meet at a right angle. When viewed from the side, this anterior cutting-edge is seen as a narrow, beveled cusp, and from its base the tooth is continued backwards as a horizontal process, the length of which is equal to the broad diameter of the tooth. The edges of the cusp and the tip of the backward-directed point are covered with brownish enamel.

The hypapophyses are present on the anterior vertebræ and absent on the posterior. They have a moderately long base.

In the writings of Cope\* this form is credited with possessing a coronoid bone. By Mr. Boulenger, however, it is placed in the category of those in which this structure is absent. Two specimens have been examined and no vestige of the bone can be found.

The external landmarks of the principal viscera in terms of gastrosteges are as follows:—

Total number of gastrosteges.....	177	100 p. cent.
Apex of heart .....	52	29·4
Liver, anterior tip .....	64	35·1
„ posterior end .....	116	65·3
Gall-bladder, middle .....	129	73
Kidney, right, anterior tip .....	146	82·5
„ „ posterior end ...	155	
„ left, anterior tip .....	150	85
„ „ posterior end ...	161	
Ileo-cæcal valve .....	157	88·8

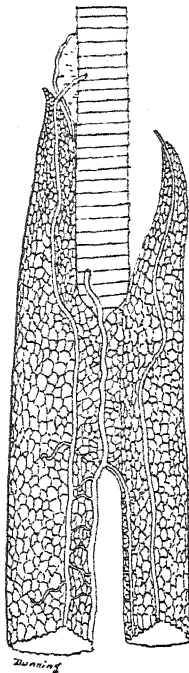
The heart is large, and its position is indicated on the thoracic walls by a distinct bulging. Over the base of the organ there are two areas in which the scales are enlarged; each area is triangular, with the base along the edge of the ventrals and the apex at the upper border of the fourth row. In the first row are five scales, each of which is one-third larger than those before or behind the heart. The scales in the seven dorsal rows are not altered. The increase in the diameter of the body over the heart is compensated for by an increase in the size of the scales in the outer rows, and not by the interpolation of an additional series.

The tracheal rings are complete from the glottis to the ninth gastrostege. From this point the rings are interrupted, and the

\* *Croc., Liz. & Sn. N. Amer* 900, p. 731.

dorsal wall of the trachea is formed by the tracheal membrane which joins the ends of the incomplete rings. From the 9th to the 21st gastrostegs the ends of the rings are in contact and the membrane lies collapsed above them. From this point to the base of the heart, the membrane widens and the ends of the rings are permanently separated. Dorsal to the heart the tracheal membrane winds around to the right side of

Text-fig. 78.

Base of the lungs of *Xenopeltis unicolor*.

Viewed from below; the object being to display the bridge uniting the two lungs, the termination of the trachea, the long free apex of the left lung, the adherent apex of the right lung, with its tiny free tip, and anterior to it the portion of the tracheal membrane which is lined internally with pulmonary tissue and is bordered by a branch of the pulmonary artery.

the tube, and 2.5 mm. before the trachea enters the lung it becomes lined with pulmonary tissue. The two lungs are adherent for a distance of 10 mm., the connecting bridge extending from the 53rd to the 57th gastrostegs. Viewed from within, this bridge appears as a septum lined with alveoli and

dividing one lung from the other. There are two perforations affording communication between the lungs; the larger, measuring 2 mm. in diameter, is at the termination of the trachea, and the smaller, measuring 1 mm. in diameter, is near the posterior border of the septum. The trachea ends abruptly 3 mm. behind the apex of the heart, and on the lower surface of the bridge.

The right lung extends from the 49th to the 119th gastrostege. Anteriorly, it reaches 8 mm. beyond the border of the bridge; it is adherent to the right side of the trachea for the distance of 6 mm., and has a free apex 2 mm. long. The trachea communicates with the lung 2.5 mm. behind the point where they join.

The left lung extends from the 50th to the 77th gastrostege. Anteriorly it terminates in an acutely pointed free apex 8 mm. long, at the level of the auriculo-ventricular septum. Posteriorly the lung terminates in a blunt cone, and towards the end the walls are a trifle thinner and the alveoli larger. There are two pulmonary veins. The right courses along the angular ventral border of the right lung and enters the anterior inferior corner of the auricle. The left commences at the posterior border of the bridge and enters the posterior inferior corner of the auricle. This vein is the thicker of the two. It is formed of two branches that arise along the mesial side of each lung; the branch from the right lung is the larger, and it has frequent anastomoses with the right pulmonary vein.

The liver extends from the 64th to the 116th gastrostege. There is no trace of segmentation.

The centre of the gall-bladder is at the 129th gastrostege.

The right kidney extends from the 146th to the 155th, and the left from the 150th to the 161st gastrostege. Each is semidivided into nine irregular lobes. The right kidney is supplied by two renal arteries, the anterior entering at the second and the posterior at the sixth lobe. There is a single renal vein leaving the anterior tip of the organ, and this promptly unites with its fellow to form a common trunk.

The lining of the rectum is smooth. The ileo-cæcal valve is at the 157th gastrostege. The rectal cæcum is 9 mm. long, and is directed forwards and lies on the right side of the ileum. Its walls are thin, and the opening into the cæcum is just anterior and to the right of the valve. Its lumen was filled with faecal matter, though the cæcum and rectum were empty.

Along the dorsal wall of the cloaca there is a longitudinal, rounded ridge, which terminates in a papilla 1 mm. in length, and at the level of the posterior border of the last gastrostege. This ridge is formed by the two parallel tubes of the completely divided vagina; these terminate in two separate orifices at the tip of the papilla. The lining of the vagina is finely and longitudinally plicate. According to Cope\* the vagina in the Peropoda is undivided and the walls are nearly or quite smooth,

\* *Op. cit.* p. 700.

and in the Colubroidea the organ is bilobate and the walls have deep longitudinal grooves. This form more closely resembles the latter.

*CYCLOCORUS LINEATUS* Reinhardt.

*Specimen.* No. 15240. California Acad. Sci. Olongapo, Luzon, P.I. Female; total length 503, tail 81 mm.

*Squamation.*—Scale-rows 17 anteriorly; the V row suppressed at the 127th gastrostege on the right and the 125th on the left, leaving 15 rows which are continuous to the vent. The last scale in the row that is dropped is before an enlarged scale in the row below. Anteriorly an oblique series of scales starting at one gastrostege terminates at the tenth to the rear. Gastrosteiges 163. Anal entire. Urosteiges 41, single. Præoculars 2, postoculars 2. Anterior temporals 2, posterior 2. Supralabials 8; the third to the fifth entering the eye. Infralabials 9; the first to the fifth in contact with the anterior genaeals. Anterior larger than the posterior genaeals.

*Anatomy.*—The hypapophyses on the dorsal vertebrae are continuous throughout the column. On the vertebra above the 122nd gastrostege the base of the hypapophysis occupies the posterior one-third of the centrum; the apex is horizontally truncate, and extends a trifle posterior to the vertical of its centrum. The caudal vertebra at the level of the 12th urostege has two triangular hæmapophyses the bases of which occupy the posterior half of the centrum. The inferior zygapophyses are developed as broad wing-like plates, 1.4 mm. long.

The maxillary bone at the junction of the anterior and middle third is bent inwards at an angle of  $45^{\circ}$ , and the teeth are arranged in two groups. The first set consists of 7 teeth that are mounted on the anterior one-third of the bone; the first five are very small and increase in size posteriorly; the sixth is nearly three times the size of the fifth, and the seventh is larger still, being 1.5 mm. long. These teeth are inclined backwards. The two groups are separated by an interval of 1.5 mm. The second set contains 13 teeth; the first nine are small and nearly equal; the tenth to the fourteenth increase rapidly until the last is twice the size of the ninth. These teeth are inclined towards the median line. The anterior tip of the palatine bone reaches the interval between the fifth and sixth maxillary teeth; there are 16 teeth. The pterygoid bone bears 19 teeth; these are on a line that is convex externally; the middle teeth being three times as far from their fellows on the opposite bone as are the teeth at the extremes. The dentary bone is also bent inwards at an angle of  $45^{\circ}$ , and has the teeth in two groups. The first set is mounted on the inflexed portion of the bone, and consists of 6 teeth; the first to fourth gradually increasing in size; the fifth and sixth strongly enlarged. The two groups are separated by an interval which is shorter than the sixth tooth. The second set consists of 17 very small teeth.

The external landmarks of the principal viscera in terms of gastrosteges are as follows:—

Total number of gastrosteges ...	174	100 p. cent.
Apex of heart .....	37	21·3
Liver, anterior tip .....	44	25·3
„ posterior end .....	96	55·1
Gall-bladder .....	114	65·3
Kidney, right, anterior tip .....	142	81·8
„ „ posterior end ...	149	85·8
„ left, anterior tip.....	144	82·8
„ „ posterior end .....	151	86·8
Ileo-cæcal valve .....	154	88·5

The tracheal membrane begins at the glottis, and for a short distance lies along the right side of the tube. Almost immediately it broadens, and at gastrostege 14 it is lined with respiratory tissue. At gastrostege 22 the membrane alters its position so that it forms the dorsal instead of the right wall of the trachea. Well above the apex of the heart the alveoli on the membrane have assumed the same size and shape as those in the lung; there is no gross difference to indicate the ending of one structure and the beginning of the other. The trachea terminates abruptly 7 mm. posteriorly to the apex of the heart. There is no rudimentary lung. Anteriorly the walls of the lung are thick and lined for the entire circumference with pulmonary tissue; posteriorly they become thin and terminate in an air-sac. The lateral lobes of the liver are distinct. The left lobe is the longer; anteriorly it extends beyond the right lobe 6 mm. and posteriorly 11 mm. There are four transverse fissures on the left lobe near the anterior tip, the rest of the organ is smooth. The anterior one-third of the rectum is thickly and regularly plicate; the posterior two-thirds are irregularly folded. There is no body to the vagina. The organ is bilaterally divided into two separate tubes that open into the dorsal wall of the cloaca by two separate orifices, which are 2 mm. apart.

*Notes.*—This species is described as having scales with apical pits, and an eye with a round pupil. Over a dozen specimens have been studied and the pits cannot be made out. The pupil is usually round in the young and frequently vertically oval in the adult.

#### CHRYSOPELEA ORNATA Shaw.

*Specimen.* No. 16707. California Acad. Sci. Cochin China. Female; total length 910, tail 237 mm.

*Squamation.*—The number of scale-rows on the body, the sequence in which they become suppressed, and the gastrostege level at which they terminate on each side may be thus presented:—

17 rows, IV row ends, right	137th, left 136th	gastrostege, leaving:
15 „ VIII „ „ „	137th, „ 138th	„ „
13 „	which are continuous to the vent.	



Gastrosteges 227, the last shield divided. Anal entire. Urosteges 120 pairs. Supralabials 10; the fifth to the seventh entering the eye; on the right the fourth is reduced and fused with the posterior inferior angle of the third. Infralabials 10 on the left, 11 on the right, the additional shield is between the corresponding third and fourth. Anterior genaeals larger than the posterior, the right in contact with four and the left with five infralabials. Gular shields in six pairs.

*Anatomy.*—Maxillary bone with 20 teeth, the posterior three with a broad shallow groove; the five preceding these are also grooved but less distinctly. Palatine bone with 8 teeth, increasing in size posteriorly; the anterior tip of the bone reaches to the interval between the second and third maxillary teeth. Pterygoid bone with 28 teeth. Dentary bone with 18 teeth, the anterior enlarged and grooved on the external quadrant.

In terms of gastrosteges the external landmarks of the viscera are as follows:—

Total number of gastrosteges .....	227	100 p. cent.
Apex of heart .....	58	25.6
Liver, anterior tip .....	73	32.2
„ posterior end .....	112	49.4
Gall-bladder, centre .....	232	58.2
Kidney, right, anterior tip .....	183	80.8
„ „ posterior end .....	201	89
„ left, anterior tip .....	196	86.5
„ „ posterior end .....	214	94.2
Ileo-caecal valve .....	209	92.2
Vaginal cornua, base .....	216	95

The cartilaginous rings of the trachea are complete from the glottis to the angle of the jaw; from this to their termination on the ventral surface of the lung, at the apex of the heart, they are interrupted. The tracheal membrane begins with the semi-rings; it is on the right side of the tube, and is continued caudad to the base of the heart. For the greater part of its length it comprises more than half the circumference of the tube. At its termination it becomes continuous with the pulmonary pleura. The elasticity of the rings maintains their free ends in close apposition, and the membrane lies in a lax state by the side of the trachea. When the windpipe is dilated, the ends of the rings are separated and the tracheal membrane becomes a functioning part of the organ. Under ordinary conditions the air passes only through that part of the tube that is formed by the semi-rings. Anteriorly the pulmonary tissue begins at the level of the auriculo-ventricular septum. In the lung it is confined strictly to the dorsal half of the circumference. Posteriorly it is drawn out as a fine streak from which are sent out transverse septa; it terminates on the left side of the air-sac, at the level of the 79th ventral. Posteriorly the lung is continued as a membranous air-sac; exactly where it ends cannot be

ascertained. There is a small rudimentary lung, a mere vesicle without pulmonary tissue. The anterior tip of the liver is not divided into lateral lobes; posteriorly the left lobe is about three times as thick as the right, and is 5 mm. longer. The surface is smooth, there being no transverse fissures. The ileo-caecal valve is at the 209th gastrostege; there is no cut-off tube or rectal-cæcum. The lumen of the rectum is longitudinally plicate, with faint closely-set transverse ridges. The vagina bifurcates at the level of the 216th gastrostege, the walls are smooth.

*Habits*.—The observations made by Mr. Shelford\* on the aerial locomotion that this serpent indulges in afforded one of the most interesting field-notes on a reptile that has been published for some time. Attention was drawn to the hinge-lines along the gastrosteges, and to the habit of retracting the middle section of these shields "so that the snake became deeply concave along the ventral surface". This serpent has been captured several times in Luzon, and the same performance witnessed. If the lung in this species had thick walls for its entire circumference, this radical change in the shape of the body could not be so readily brought about. On the contrary, it is so modified that when subject to ventral pressure it merely has the lower membranous wall stove in and no serious interference with respiration takes place.

#### *CROTALUS CONFLUENTUS* Say.

*Specimen*. Field No. 8208. U.S. Nat. Mus. Mt. Tamilpais, alt. 650 M., California. Female; total length 460, tail 45 mm.

*Squamation*.—The number of scale-rows on the body, the sequence in which they become suppressed, and the gastrostege level at which they terminate on each side may be thus presented:—

25 rows, VI row ends, right 108th, left 160th gastrostege, leaving:

23	"	V	"	"	"	123rd,	"	124th	"	"
21	"	VIII	"	"	"	165th,	"	162nd	"	"
20	"	X	"	intermittent	between	124th	and	165th	"	"
19	"			which are continuous	to the	vent.				

Ventrals 174. Anal entire. Urosteges 21 entire, the first and last three paired. Præoculars 2, suboculars 2, postoculars 4. Supralabials 14 on the right, 13 on the left side; the reduced count due to the fusion of the fourth and fifth shields.

*Anatomy*.—The external landmarks of the principal viscera in terms of gastrosteges are as follows:—

Total number of gastrosteges	...	174	100	p. cent.
Apex of heart	.....	70	40.2	
Liver, anterior tip	.....	70	40.2	
" posterior end	.....	109	62.5	

\* "A Note on 'Flying' Snakes," P. Z. S. 1906, p. 227.

Kidney, right, anterior tip .....	144	82.8 p. cent.
"    "    posterior end ...	163	
"    left, anterior tip .....	146	84
"    "    posterior end ...	166	
Vagina, apex .....	164	99.2

The cartilaginous rings of the trachea are complete from the glottis to the 6th gastrostegae. At this point the tracheal membrane begins on the dorsal quadrant of the tube. Almost immediately, while still very narrow, it acquires pulmonary tissue, this rapidly increases and becomes continuous with the lung. The semi-rings extend along the ventral surface of the trachea; viewed from within they appear as a narrow gutter; they terminate 15 mm. caudad from the apex of the heart. The walls of the lung posterior to the heart have a very thin lining of pulmonary tissue; the alveoli are large and shallow in contrast with those in the trachea, which are small, thick, and superimposed. In other words, the area of the respiratory tissue in the lung is much less than it is in the trachea. The liver is deeply divided into a right and left lobe, and these are partially divided by shallow and transverse fissures. Anteriorly the left lobe is thick and rounded, extending three gastrosteges beyond the right, and overlapping the apex of the heart by 1 mm. The peritoneum covering the liver and the abdominal walls is pigmented, the remainder is plain. The vagina is short, it extends over 10 gastrosteges, and is bilobate. The cornua are adherent to each other at the base for a distance of 1.5 mm. Externally each horn gives the appearance of being composed of two adherent tubes, with the oviduct entering the outer. The lining is smooth, and is thrown into several longitudinal folds; two of these are larger than the rest, and their free edges nearly touching tend to divide the lumen of each horn into an inner and an outer compartment.

#### *The Intromittent Organ.*

*Polyodontophis bivittatus* Boulenger.—The hemipenis is undivided and the sulcus simple. The base is plicate and is followed by a spinous zone 4 mm. in length. The spines are about ten in number; there are two placed opposite to the sulcus that are much enlarged, being 2.5 mm. in length. The distal 6.5 mm. of the organ is calyculate. The calyces are very small and their borders bear numerous minute spines. The calyces at the border of the spinous zone and at the tip are enlarged, the latter have simple borders.

In Cope's classification the enlarged basal hooks place this form in the *Natricinae*. The occurrence of these hooks with a calyculate apex represents a divergence in the direction of the *Colubrinae*.

*Tropidonotus vibakari* Boie.—The hemipenis and the sulcus spermaticus are undivided. The organ is densely spinous; those on the middle are a trifle the larger, diminishing in size towards

the apex and the base. There are a few enlarged basal hooks situated close to the sulcus, one being on one side and four on the other; of these four the one nearest the base is double the size of any of the others. The tip of the organ is rounded and smooth, and the line of demarcation between the bare and the spinous areas is sharp. On either side of the smooth area at the tip, there are mounted two apical papillæ, which are one-fourth the length of the body of the organ. Each papilla is spinous for three-fourths of its circumference, the inner quadrant being smooth and continuous with the spineless area at the tip.

Terminal papillæ similar to those in this species are of comparatively rare occurrence. Cope has reported them in the genus *Oligodon* Boie, and in the three following species: *Tropidonotus vittatus* Linnæus, *Ischnognathus lineatus* Hallowell, and *Coluber helence* Daudin. Each of these has been set apart by Cope as the type of a new genus, established on the ground that the intromittent organ differed widely from the type prevailing among the nearest allies. *T. vibakari* in this respect is clearly separated from the Far Eastern representatives of the genus. These have been placed in the genus *Bothrodytes* by Cope, and are characterized by having the organ furcate. The organ in *vibakari* most closely resembles that found in *Ischnognathus lineatus* Hallowell, and the figure given by Cope\* of this species shows that it differs from *vibakari* in the one detail of being less completely covered with spines. Furthermore, this serpent is of precisely the same mild-actioned and fearless nature that is characteristic of the species of *Ischnognathus*. In this it offers a marked contrast with the Far Eastern members of the genus *Tropidonotus*. Over a dozen species of these have been captured and every one showed a nervous, irritable, and snappy disposition.

To allow this species to remain in a complex genus like *Tropidonotus*, after it has been found to differ so radically, is not good taxonomy. On the other hand, to chronicle promptly each new anatomical discovery under a new generic caption does not materially aid our studies. It is believed that the dilemma can be overcome for the time being by strictly adhering to the nomenclature contained in the 'Catalogue of Snakes in the British Museum,' and at the same time by registering a provisional new generic term. This new term is not to become current until the entire group to which it belongs has been re-examined from the standpoint of comparative anatomy.

With this understanding it is suggested that the new genus *Hebius* be established for *Tropidonotus vibakari* Boie, the salient character distinguishing it from all species of *Tropidonotus* being the densely spinous and undivided hemipenis, bearing two long apical papillæ.

*Helicops angulatus* Linnæus.—The total length of the hemipenis is 42 mm.; it is divided into two quadripenes, the length

\* *Op. cit.* pl. xx. fig. 12.

of each being 10 mm. The quadripenis is calyculate, and the cells are arranged in seven rows that trend obliquely forward from the sulcus. The distal half of the body of the hemipenis is spinous: opposite to the sulcus there is a septal fold. The proximal half is plicate. At the border of the spinous area and close to the sulcus there are two round, flat-topped, and gristle-like papillæ; these are closely set and one is distal to the other. The sulcus is divided at a point 12 mm. from the base, this is well within the plicate area.

Mr. Rosén\* writes that the hypapophyses are absent from the posterior vertebræ in *H. modestus* Günther and *H. leopardinus* Schlegel. In this species they are well developed throughout, one occurring even on the last dorsal vertebra.

*Cyclocorus lineatus* Reinhardt.—The hemipenis is of extreme length and slenderness, being 38 mm. long and 2 mm. in diameter. It is not divided and the sulcus is simple. The base for the distance of 4 mm. is plicate; the remainder of the organ, even to the tip, is spinous. Towards the tip there are three slightly elevated longitudinal ridges, one 8 mm., the others 5 mm. in length. The spines are nearly uniform in size, being about .3 mm. to .4 mm. long. Each is mounted on a broad fleshy base, and is slightly recurved. When the walls are stretched the spines are seen to be arranged in longitudinal series.

*Spilotes pullatus* Linnaeus.—The structure in this species is one of the most complicated recorded. The total length of the hemipenis from the base to the insertion of the retractor muscle is 77 mm. The organ and sulcus spermaticus are undivided. From the base to the 20 mm. point are longitudinal plications; the folds are thick, at first straight, later becoming wavy. From the 20 mm. to the 38 mm. point it is densely beset with stout, blunt spines, each of which is about 2.5 mm. long. From the 38 mm. to the 54 mm. point on each side of the sulcus are rows of flounces, these trend obliquely forward and acquire partitions which convert them into rows of calyculi; the cells of these calyculi increase rapidly in size, the largest being situated opposite to the sulcus. On each side of the sulcus at the 60 mm. point are two thick flaps 10 mm. long; these are in the longitudinal plane, hang free in the lumen of the organ, and are covered with small regular ruches. Between one of these flaps and the sulcus there is a thin membranous septum 20 mm. long, parallel to the sulcus, and hanging free in the lumen. Towards the extremity of the organ the calyculi change to irregular flounces; these in turn are converted at the extreme tip into minute frills.

United States Fisheries Steamer 'Albatross',  
Sausalito, California, April 1st, 1913.

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\* Ann. Nat. Hist. (7) xv. 1905, pp. 170-171, fig. 1.

### 33. The Polyzoa \* of Waterworks. By SIDNEY F. HARMER, Sc.D., F.R.S., F.Z.S.†

[Received March 11, 1913: Read April 22, 1913.]

(Plates LXII. & LXIII.‡)

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#### I. Historical Account.

It is perhaps not generally recognized in this country that, under certain circumstances, Polyzoa may be of great economic importance. But it has long been known to those interested in the subject, particularly in Germany, Holland, Belgium, and the United States, that a group of organisms, among which certain Polyzoa play a leading part, may flourish in the pipes of waterworks which are not provided with an efficient filtering apparatus, to such an extent as to give rise to the most serious inconvenience, and may indeed finally throw the whole system out of gear. It is the object of this paper to show, by means of examples which have come under my notice during the last two or three years, that this country is by no means exempt from the risks which have been experienced in various places abroad.

The first important contribution to the subject was an extremely interesting paper by Kraepelin (85), published under the title of "Die Fauna der Hamburger Wasserleitung"; although, as Kraepelin himself points out, a list of 18 species of animals from the pipes of the same water-supply had been published by Petersen some nine years earlier. The occurrence of such organisms as *Asellus* and *Gammarus* in the water supplied to houses in Hamburg was no rare event in that city; while the pipes were frequently choked by Eels, "Leitungsmoos" and other organisms. Kraepelin undertook a biological investigation of the subject, influenced partly by the hope of finding blind Crustacea among the inhabitants of the water-pipes, to which

\* [In view of the difference of opinion as to whether this Phylum should be called Polyzoa or Bryozoa (see Proc. Linn. Soc. 1911, p. 61), I have accepted the preference of the author.—EDITOR.]

† Published by permission of the Trustees of the British Museum.

‡ For explanation of the Plates see p. 456.



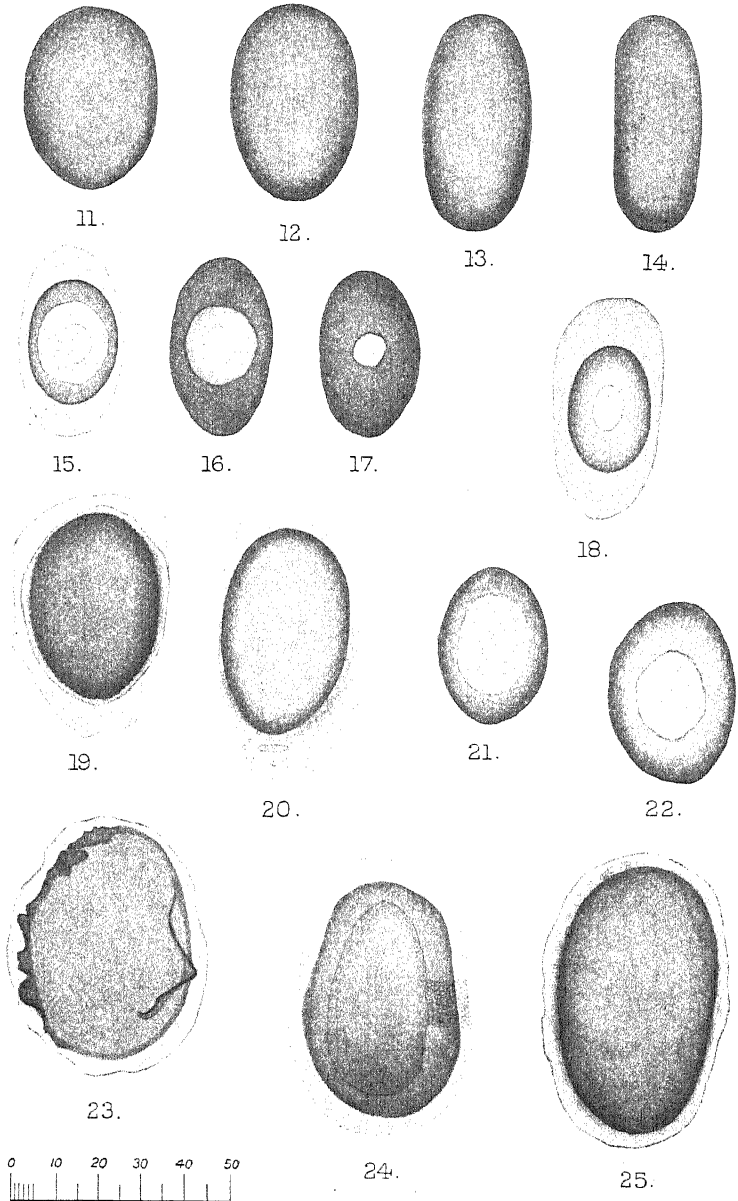
S.F. Harmer del.

Bale & Danielsson, L.<sup>13</sup> imp.

PALUDICELLA ARTICULATA.







S. F. Harmer del.

Bale & Danielsson, 1<sup>st</sup> imp.

STATOBLASTS OF PHYLACTOLAEMATA.



light had, of course, no access; and by the further consideration that he might be able to detect some modifications of structure, as compared with the ordinary inhabitants of the Elbe, in the animals which were living under these unusual conditions. Although the results of the investigation were not of the nature which he had anticipated as possible, they were nevertheless very surprising; since he was able to demonstrate that some fifty genera of animals occurred, often in enormous numbers, in the system. The examination was made with the assistance of a specially devised piece of apparatus which was screwed on to various parts of the water-mains. A column of water was allowed to escape through this arrangement, and the animals which were contained in it were filtered off. The results obtained were very uniform, in whatever part of the system the apparatus was used, so that it became clear that the organisms found were not merely a fortuitous collection of individuals which had accidentally been introduced into the supply, but were, on the contrary, perfectly normal constituents of a definite fauna inhabiting the water-pipes under a pressure of  $2\frac{1}{2}$ – $5\frac{1}{2}$  atmospheres. Among these organisms a conspicuous, and usually the greater, part consisted of large masses of what had become known to the workmen as "Leitungsmoos"—a mass of entangled tubes which belonged principally to Polyzoa of the genera *Fredericella*, *Plumatella* and *Paludicella*, but partly to the well-known Hydroid *Cordylophora*. Sponges (*Ephydatia fluviatilis* and *Spongilla lacustris*) were frequently found. Colourless forms of *Hydra* were discovered; but, as might have been expected, *H. viridis* appeared to be completely absent. Several species of Freshwater Oligochaetes were recorded, as well as "almost incredibly large numbers" of Leeches (*Glossiphonia* and *Nepheleis*). Parasitic worms were represented by *Echinorhynchus*, found in large numbers, in its larval condition, in *Asellus*; and, in its adult condition, apparently derived from Eels. Among the Polyzoa the "mossy" appearance of the masses of tubes above alluded to was generally due to *Fredericella sultana*. Traces of *Paludicella articulata* were generally found: while *Plumatella* was represented principally by a form described by Kraepelin as *P. princeps*, var. *muscosa*, and by the Alcyonelloid *P. fungosa*. Almost every sample contained hundreds, or indeed thousands, of *Asellus aquaticus*, which were found creeping over the Polyzoa "in ugly crowds." The Freshwater Shrimp, *Gammarus pulex*, was somewhat less numerous, while various forms of Cladocera, Copepoda, and Ostracoda were nearly always present. *Leander* [*Palaemon*] *squilla* and *Mysis chamaleon* were represented by single finds. A small water-mite and a few Dipterous larvæ and pupæ were rarely met with.

Among Molluscs the commonest species was *Dreissensia polymorpha*; but *Bithynia tentaculata* was frequent, and other freshwater genera—*Physa*, *Limnæa*, *Planorbis*, *Ancylus*, and *Sphaerium* (*Cyclas*)—were also discovered; while Petersen had previously

recorded *Vicipara* (*Paludina*), *Anodonta* and *Unio*. Planarians and a Nemertine (*Tetrastemma*) were also found, although the method employed for collecting the samples was not well adapted for the discovery of the smaller organisms. Rotifers and Infusoria (*Porticella*, *Stentor*, *Paramecium*, and *Acineta*) were, however, discovered.

Even the Vertebrates were not unrepresented in this remarkable fauna. The Eel, up to a foot in length, was common. As many as six individuals were sometimes present in one sample, and Kraepelin estimated that there must have been many thousands in the system. Other fishes were less numerous; but the Stickleback (*Gasterosteus aculeatus*) was occasionally found; and on one occasion a Burbot (*Lota vulgaris*), a foot in length, was discovered. A young Flounder, several centimetres long, was found in company with the Prawn (*Leander*) above alluded to.

Summarizing his observations, Kraepelin points out that the constituents of the fauna of the water-pipes consist almost exclusively of forms which feed either on detritus or on one another; that in the absence of ordinary green plants, forms which feed on these are absent; while animals like insects, which require access to air, are also absent. For the species which had succeeded in adapting themselves to their novel environment the conditions were, on the contrary, exceptionally favourable, and indeed more favourable than those found normally in Nature. Some of the factors specially alluded to, in this connexion, were the absence of carnivorous insects, and the existence of large surfaces suitable for the attachment of sessile animals.

Kraepelin proceeds to consider the ultimate source of the food of the pipe-fauna; and he points out that this must consist of the microscopic organisms and other detritus introduced into the system by the constant flow of water from the Elbe. The absence of any filtering arrangements, at that time, allowed these particles to enter without hindrance. In working up these materials into new organic substances the Polyzoa played a part of pre-eminent importance; particularly since these animals formed so large a proportion of the entire fauna. The carnivorous animals naturally depended for their supply of food on the organisms which were able to make use of the microscopic detritus. Kraepelin accordingly arrived at the perfectly legitimate conclusion that if the food-supply were to be cut off by the introduction of an efficient filtering arrangement, the pipe-fauna would before long die out. The soundness of this conclusion was amply demonstrated by the cessation of the trouble at Hamburg on the introduction of the remedy suggested; while the experience of Water Engineers in many other places has been of a similar nature.

The presence of Polyzoa in water-pipes is, however, not an unmixed evil; since, as has been pointed out by several observers, if floating organisms exist in the water, the Polyzoa serve the

purpose of removing many of them. But any good they may do in this way is more than counterbalanced by other inconveniences. One of the most obvious of these is the diminution of the calibre of the water-pipes, which may take place to such an extent as seriously to interfere with the circulation. Thus Kennen (99, p. 46) mentions a case which had come under his own observation of a pipe 60 cm. (about 24 inches) in diameter, which was encircled, on its inner side, by a layer of Polyzoa 15 cm. (6 inches) in thickness. It has further been found by Water Engineers who have been confronted with this difficulty that, as the Polyzoa disintegrate, masses of the tubes are torn off from the walls of the pipes and pass into the circulation. They thus pass to the smaller pipes of the domestic supply, where they give endless trouble by choking the ball-taps and strainers of the meters to such an extent as to stop the supply of water.

These are, however, by no means the only troubles which result from the presence of Polyzoa and other organisms in the water-supply. It is the habit of Freshwater Polyzoa, in these latitudes at least and in the state of nature, to die towards the approach of winter. There is evidence that even in the sheltered conditions under which they live in water-pipes protected from the weather, they are not entirely insensible to seasons; although it may be noted that Kraepelin (85, p. 12) points out that many of the constituents of the pipe-fauna were found, in the depth of winter, at a time when the water containing organisms living in exposed places was covered with ice and snow, in a condition differing but slightly from that in which he had found them in the summer. But he adds that the polypides of *Plumatella* were all dead at this time (December), although in March the hibernacula of *Paludicella* were splitting (as a preliminary to germination), and the statoblast—"embryos" of *Fredericella* were already escaping from their shells. Owing to the death of the polypides of the Polyzoa, at the approach of winter, a certain amount of decomposition of organic material naturally occurs. This sets up further troubles, partly by tainting the water and partly by providing material which encourages the growth of Bacteria. The tainting of the water, which may be due to a combination of these two factors, is sometimes very serious. Thus De Vries (90, p. 38) records a case of this kind in which even horses would not drink the water.

It is not my purpose to discuss the flora of the filtering-beds and water-pipes—a subject of great biological interest with which I do not feel myself competent to deal—but it is necessary to refer to an illuminating study of this question which was made, in 1890, by Hugo De Vries, in the memoir just referred to. The town of Rotterdam is supplied by water from the Maas. The waterworks were established in 1874, and at first gave no trouble. In the spring of 1877 serious difficulties began to be experienced as the result of a sudden invasion of "Iron-Bacteria," and in particular of a form described by De Vries

as *Crenothrix Kühniana* (= *C. polyspora* Cohn). A scientific Commission was appointed to investigate the matter; and the memoir cited was the result. The Bacteria in question, which grow associated in long filaments, flourish in the presence of iron in solution in the water. Under these conditions, and when provided with the requisite organic matter, they deposit the iron, in an insoluble form, in the sheath which forms the outer part of the filament. Where they are present in sufficient numbers they then flake off the inside of the pipes in masses which pass into the circulation and are delivered with the water into the domestic supply, where they cause great annoyance. This result may become a serious calamity by rendering the water extremely unpleasant for domestic use, and completely unusable for many industrial purposes (De Vries, 90, p. 9). The remains of animals and plants which have died in the pipes are said to provide the organic matter which is required by the Iron-Bacteria. The growth of these organisms is commonly associated with the formation of a hard deposit on the inner sides of the pipes; and this may give rise to serious trouble by reducing the flow of water.

I am indebted to my colleague Mr. A. Gepp, of the Botanical Department of the British Museum, for calling my attention to some of the special points of interest in connexion with Iron-Bacteria. A good general account of the subject may be found in De Vries' memoir and in the works of Lafar (98, 04), while an extensive bibliography is given on pp. 90-92 of one of Kemna's memoirs (05). One of the special points of interest in this connexion is the theory, first brought forward by Winogradsky, that the Iron-Bacteria take up iron in solution in the ferrous state and obtain their energy by oxidizing it to the ferric state, which appears in the form of iron-rust deposited in the sheaths of the filaments. The theory has been criticised by some of the more recent workers, as by Molisch, who claims to have kept Iron-Bacteria for several generations in iron-free solutions. It has been suggested that the deposit of iron-rust in the sheath of *Crenothrix* and other forms is of the same general nature as the appearance of silica in the cell-wall of a Diatom: and that it has not the physiological significance which was attributed to it by Winogradsky. But whatever the nature of the process may be, the peculiar property possessed by these Bacteria of depositing iron in the ferric state is a matter of the utmost practical importance to Water Engineers.

The removal of the pipe-fauna, or the establishment of conditions under which a fauna of this kind cannot effect an entrance, appears to be of great importance in preventing the growth of Iron-Bacteria. As De Vries pointed out, these organisms require organic matter, which is supplied to them in abundance, in unfiltered water, by the disintegration of the constituents of the pipe-fauna. An instructive case, which appears to be of this nature, is discussed by Kemna in his account of the troubles

which have been experienced at Liverpool. In order to increase the supply of this city a dam was constructed at Vyrny, in Wales. Filters were installed at Oswestry, thirty kilometres from the dam; and the water was then carried for about twice that distance to Liverpool. In this latter part of the system no difficulties have been experienced; but in the part which carries the water from Lake Vyrny to the filters, constant trouble has been caused by the formation of a mucilaginous layer which seriously reduces the calibre of the pipes. In the deposit thus formed Kemna states (05, p. 78) that he has found *Crenothrix*, one of the Iron-Bacteria.

Although De Vries was principally concerned with the study of *Crenothrix*, he did not restrict himself to the consideration of the flora of the system. He points out (pp. 34, 35), as the result of his observations, that the fauna in the Rotterdam water-pipes is closely similar to that which had been found by Kraepelin at Hamburg. Among the organisms thus recorded, *Cordylophora*, *Paludicella*, and two forms of "*Plumatella*" [one of which may have been *Fredericella*] were important constituents. Here, as at Hamburg, deficient filtration was the real cause of the trouble. In parts of the system where the conditions were favourable, owing to faulty construction of the filters, some of the animals occurred in astonishing profusion. I may refer specially to certain Crustacea (*Asellus* and *Gammarus*), which were found in almost incredible numbers. This is brought out sufficiently clearly by the observation recorded on p. 65 of the memoir cited, that the bottom of one of the filters was found to be coated by a continuous layer, of almost the thickness of a finger, of the feces of *Asellus*, while the animals themselves occurred in "countless millions"!

De Vries' memoir gives references to other cases of waterworks which have at various times suffered seriously from the occurrence of Iron-Bacteria or an unduly rich fauna, or both combined. Among these I may mention the "Berlin water-calamity," in 1878 onwards, which was completely cured by the introduction of sand-filtration in 1883 (pp. 9, 14, 15, 37); Philadelphia (p. 35); and Lille (p. 37). Further information with regard to cases which have occurred in America is given by Whipple (10), who mentions Boston, where Polyzoa, especially *Fredericella* and *Plumatella*, were the most important constituents of the fauna. Other cases recorded are Brooklyn (p. 169) and Henderson, N.C. (p. 123). In addition to the genera of Polyzoa which have already been mentioned as occurring in drinking-water, Whipple gives *Pectinatella* and *Cristatella*.

There is some reason to believe that the Corporation of Manchester has suffered from troubles of a similar nature to those experienced at Hamburg and Rotterdam. Hickson (04, p. 675) has stated that, two years before the date of his Address, the mains had become partially blocked by the growth of an organism which was described as a "moss," but which Hickson had the

opportunity of inspecting and thus satisfied himself that it was really composed of Polyzoa. 700 tons of this "moss" are said to have been removed from the mains by an expensive and laborious process; but the subject was not investigated biologically, and I have been unable to ascertain anything more with regard to the subsequent history of this case.

At Paris (*cf.* Kemna, 05, p. 26) the Molluscan fauna of the water-pipes was investigated by Locard, who recorded 44 species, belonging to 13 genera.

At Ypres, in Belgium (Kemna, 05, p. 63), a quantity of shells, with masses of Polyzoa and innumerable Infusoria, could easily be obtained by opening a hydrant in the streets.

Mr. S. C. Chapman, M.Inst.C.E., the Water Engineer to the Borough of Torquay, to whose kindness I am indebted for much information on the subject of waterworks, is preparing a paper in which he proposes to give an account of the troubles which have been experienced in the district supplied by the system under his own charge, and of the result of the enquiries which he has made of the Engineers of other waterworks, at home and abroad. This paper is expected to appear in the 'Transactions of the Institution of Water Engineers.' I believe I am right in saying that it will contain valuable information tending to prove the correctness of the view, which is held by nearly everyone who has studied the subject, that the troubles which are caused by the occurrence of a rich pipe-fauna can be got rid of by the introduction of an efficient system of filtration.

Enough has been said to show that the occurrence of conditions favourable to the growth of Polyzoa and other organisms in the pipes of a water-supply is not a matter to be treated lightly. A study of the literature shows, moreover, that the Biology of waterworks is a subject of great complexity and of very special scientific interest. An excellent general account of the problems involved has been given by Dr. A. Kemna (99, 05), who speaks with special authority since, in addition to his scientific qualifications, he has had the advantage of being the Manager of an important Water-Company which supplies the town of Antwerp. As the subject is one which has not attracted much attention in Zoological literature, I may perhaps be excused for adding a few remarks, based principally on Kemna's account (05), on the subject of sand-filtration, which is so closely connected with the practical side of the question.

The introduction of sand-filters was due to James Simpson, Engineer to the Chelsea Company, who gave evidence on the subject before a Royal Commission on the Water-Supply of London in 1827-1828, and before a Committee of the House of Commons in 1828. Kemna comments (p. 109) on the fact that although Simpson's views on the theory of sand-filtration were not altogether sound, he nevertheless succeeded at his first attempt in introducing a system which has not been materially improved on since.



In this system the water is introduced into shallow filtering-beds, which are of large superficial area and have a bottom of sand through which the water passes before it is admitted to the pipes. The efficiency of the filter does not depend on a mechanical straining action of the sand, but is a biological process, principally confined to the surface-layer of the sand. In this layer grows an abundant flora, consisting of Algae and Bacteria; and the beneficial action is the result mainly of the presence of Diatoms. By means of the slimy or gelatinous investment formed by these organisms, the intervals between the sand-grains are filled up, thus increasing the effectiveness of the filter as a strainer; while the surface-film of living organisms has a very marked effect in reducing the number of Bacteria, and probably affects the character of the water in other ways. As the filter continues in action, the number of organisms in its floor increases and the surface-film grows in thickness in a corresponding proportion. The filtering surface also tends to become choked by the accumulation of detritus which has been strained off, until from these causes it ceases to transmit the water so fast as is necessary. The filter then has to be put out of action and the surface-film must be removed. The film has to be allowed to re-form for two or three days before the filter is in a condition to be used once more.

The organisms which are of importance in the filtering process undergo seasonal variations. Thus at one time of year Kemna finds that one species of Diatom is dominant, while at another time the effectiveness of the layer depends on some other species or group of species. The filter thus needs constant observation, since it may readily get out of working order. An interesting case is recorded by Kemna (99, p. 48), who found that Dipterous larvæ (*Chironomus*) may have an important practical effect. In the observation alluded to, the surface-film was inhabited by numerous larvæ, which were living in tubes constructed out of sand-grains. So long as the larvæ inhabited their tubes the filter worked well. But when they left the surface-film in order to undergo their metamorphosis, their empty tubes formed a number of perforations which were naturally not closed by Diatoms, etc., and the filter then ceased to work properly. Information that the insects were undergoing their metamorphosis was given by the appearance of Swallows circling round the filters in order to feed on the emerging Diptera. On noticing this indication the filter was put out of use and given three days' rest, during which the holes left by the emergence of the *Chironomus* became closed by a new growth of the surface-film.

The practical importance of sand-filtration is well brought out by the facts which are cited by Kemna in the two memoirs already referred to. One of the most instructive cases is the history of the Hamburg Waterworks during the years which preceded Kraepelin's investigation of the pipe-fauna. In 1842

a disastrous fire destroyed a large part of the city of Hamburg, including the buildings which contained the machinery of several distributions of water. The Municipality thereupon took over the supply of water; and it is satisfactory to learn that the English Engineer, Lindley, who is described as the author of the project, insisted on having an installation of sand-filters. Partly owing to financial difficulties, and partly in consequence of the objections raised by the manufacturers and vendors of domestic filters, Lindley's recommendation was not followed for many years. At last, however, the difficulties were overcome, and the construction of filters, which were to be completed in 1894, had commenced in 1890. Shortly after this date the water taken from the Elbe became contaminated by a temporary encampment of Russian emigrants, and cholera broke out in August 1892, before the completion of the new works. This epidemic, which claimed 10,000 victims, was clearly traced to the defect in the water-supply, since the neighbouring town of Altona, which took its water from the same source but filtered it before using it, remained unaffected. The cases which actually occurred in Altona were traced to the use of Hamburg water; while blocks of houses in Hamburg which were supplied from Altona escaped infection. Mr. S. C. Chapman informs me that he has heard from Professor Kraepelin that the introduction of filtration, "through extensive gravel-beds," was almost immediately successful at Hamburg; the pipe-fauna dying from starvation in the course of a few months after the installation of the filters.

It might naturally be anticipated that the conditions in the reservoirs and filter-beds (in the layer of water above the sand) would be favourable for the growth of numerous freshwater organisms. These are the sources from which the pipes may become colonised, if not protected by filters; and it is thus of interest to notice that the facts are in accordance with expectation. A case of this kind is recorded by Hickson (04, p. 675), where great trouble was caused in the supply of the town of Burnley by the occurrence of enormous numbers of *Limnæa peregrina* in the Hecknest reservoir. An even more striking instance is described by Kemna (99, pp. 47, 48) from his own experience in the Antwerp reservoirs, in 1896. In this case the trouble was caused by the extraordinary multiplication of Cladocera, which were so numerous that it was necessary to strain all the water passing to the filters through screens of wire-gauze. So great was the number of these small Crustacea that it was found necessary to keep six men constantly employed, night and day, in changing the strainers. The quantity of Crustacea thus removed was estimated by Kemna at ten tons at least.

Another striking case, due, however, to defective construction of the filters, is the one recorded by De Vries (90, pp. 56 *et seq.*), where enormous numbers of *Gammarus* and *Asellus* occurred in the filter-beds and other parts of the system.

It need not be a matter for surprise if a particular system should be found to have been free from trouble due to Polyzoa and other

organisms for a long period, and then to have become suddenly infected. It is at least theoretically possible that Polyzoa are absent in certain waterworks merely because no statoblast or embryo happens to have found access to the system; even though there may be nothing to prevent these organisms from flourishing if they succeed in effecting an entrance. The means of distribution of freshwater organisms have frequently been discussed. Darwin gives important information on the subject in 'The Origin of Species', Ch. xiii:—with particular reference to dispersal by water-birds and insects. Other facts of the same nature are recorded by H. Wallis Kew, in 'The Dispersal of Shells' (Internat. Sci. Series, 1893). A short general discussion of the subject was contributed by O. Zacharias to the 'Biologisches Centralblatt,' ix. Nos. 3 and 4, April 1889. Reference may also be made to B. M. Puschkarew's recent paper, "Ueber die Verbreitung der Süßwasserprotozoen durch die Luft" (Arch. f. Protistenkunde, xxviii. Heft 3, 1913, p. 323).

It can hardly be doubted that the method by which Polyzoa most commonly colonize a new place is by means of their statoblasts, which from their habit of floating at the surface are extremely likely to adhere to some part of the legs, beak, or feathers of a wading or swimming bird, or to some part of a water-insect. De Guerne (88), struck by the occurrence in the Azores of a lacustrine fauna almost entirely composed of European types, was led to examine the material adhering to the feet of Ducks; and on one occasion (p. 297) he discovered a half statoblast of a *Plumatella* on the web of the foot of a Wild Duck. Similar positive information with regard to the dispersal of freshwater Polyzoa has been published by Garbini, in a paper which I have only been able to consult by means of the notices given in Vol. ii. (p. 195) of the 'Zoologisches Centralblatt', and (by Matzdorff) in the "Jahresbericht über die Bryozoen für 1897 und 1898" in the 'Archiv für Naturgeschichte,' lxi. Jahrg., ii. Bd. Heft 3, p. 181. It appears from the latter notice that statoblasts of a *Plumatella* were found attached to the beak of a Heron ("Reiher").

## II. Occurrence of Polyzoa in British Waterworks.

I turn now to the consideration of the cases which have come under my own observation in this country. I am able to record five cases, in very different parts of Great Britain, in all of which serious trouble has been experienced. I commence by giving some account of the occurrence of the organisms, reserving the question of the determination of the specimens to Part III. of this paper. The cases are as follows:—

### (1) TORQUAY AND NEWTON ABBOT.

Towards the end of September 1910, I received samples of a *Plumatella* (*P. emarginata*, var. *muscosa*) from Mr. Samuel  
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C. Chapman, M.Inst.C.E., Water Engineer to the Borough of Torquay. I am greatly indebted to Mr. Chapman for the trouble he has taken in giving me the fullest information with regard to this particular occurrence, and in calling my attention to similar instances in other places.

The Torquay case is one of the usual kind, in which no efficient system of filtration had been in operation. In spite of this fact no trouble had been given by the growth of Polyzoa or other organisms, in sufficient quantity to give rise to anxiety, during fifty years. The apparently sudden invasion may perhaps have been due to the fact that the Polyzoa in question had not previously effected an entrance into the system. The *Plumatella* was first observed in pipes which had been in use a little more than two years. The pipes were at the bottom of a steep hill, on a trunk-main which supplied a large part of Newton Abbot, and where the flow of water was constant and of considerable velocity. The Polyzoon was soon traced in every direction all over the system, both at Torquay and at Newton Abbot. It quickly began to give rise to serious inconvenience, by becoming detached from the walls of the pipes and by being carried to the ball-taps and the strainers of meters, which became blocked and were thus thrown out of work. The trouble became specially acute immediately after a frost in the early part of 1912. This is entirely in accordance with expectation; the *Plumatella* which had been growing on the walls of the pipes having no doubt broken up during the cold weather, its branches having then passed into the flow of water and so having given rise to the choked taps and meters which were reported in large numbers. In one case mentioned to me by Mr. Chapman, eleven houses in one block of buildings were without water owing to this cause. It need hardly be remarked that the well-known habit of dying at the end of the year gives these freshwater Polyzoa special advantages in distributing themselves over a wide area of a system. It is only necessary for statoblasts or fragments of branches containing them to remain attached to some irregularity on the inside of a pipe to make it practically certain that some of them will have the opportunity of germinating in the next period of warm weather.

No complete examination of the pipe-fauna has been made in the Torquay Waterworks, but a few other animals have been observed in them. One of the most conspicuous of these is a Freshwater Sponge, which has been found growing on the insides of some of the pipes, and has been determined by Mr. R. Kirkpatrick as *Ephydatia fluviatilis*. In some of the samples there were large quantities of a Dipterous larva, of a bright red colour. These have been determined by Mr. F. W. Edwards as a species of *Chironomus*. The majority of these larvæ, and perhaps nearly all of them, could hardly have succeeded in completing their metamorphosis; and it seems probable that, as in the case of the Dipterous larvæ recorded by Kraepelin (85, p. 11), the trans-

formation into the imago, or at least the emergence of the adult form into the air, could not take place except by some chance combination of circumstances which would hardly occur very often. It may be noted that Kraepelin, in commenting (p. 11) on the absence of *Chironomus*-larvæ from the underground pipes of the Hamburg system, points out that, according to his observations, these larvæ are the most dangerous enemies of freshwater Polyzoa, whose delicate branches they tear to pieces. This might have an important bearing on the distribution of the Polyzoa, since, even in the most active period of their growth, branches containing statoblasts would be liberated by the *Chironomus*-larvæ, and some of them would come to rest in places where a new growth of the Polyzoa would be started.

In at least one of the samples, considerable numbers of a small freshwater Oligochaete were found; but I am not able to determine it from the preserved specimens in my possession.

From the descriptions which have been given to me by Mr. Chapman, there can be no doubt of the occurrence in the Torquay system of small Gasteropods (perhaps *Bithynia* or *Limnaea*, and almost certainly *Planorbis*), and of *Asellus*, *Gammarus*, Cladocera, and Copepoda. I have not had the opportunity of examining specimens of any of these animals.

I have no certain evidence of the occurrence of Iron-Bacteria, but the appearances suggest that these occurred. In some places the pipes were found to be coated with a thick black layer of "peaty substance," cemented by iron-compounds. My colleague Mr. A. Gepp, who has kindly examined one of the samples, tells me that its condition is not such as to make the demonstration of Iron-Bacteria certain, but from his experience of other similar cases, he has little doubt but that these had really been present.

It may be remarked that the Torquay authorities have now instituted a filtration-system; and, judging from the experience of other water companies, it may be presumed that the trouble from which they have suffered will soon be a thing of the past.

(2) LORD POWIS'S STYCHE ESTATE (at Lydbury, North Shropshire, near Market Drayton).

In May 1912 I received information, through Dr. Augustus Voelcker, of the Royal Agricultural Society, of the occurrence of a Polyzoon which had been giving serious trouble near Market Drayton. I later received specimens, in the fresh condition, through the kindness of Mr. R. H. Newill, Lord Powis's agent. The specimens in question were well-grown examples of *Plumatella fungosa*, var. *coralloides*. In this case a feed-tank received its water from a small open pool in which the Polyzoon was proved to be growing. The water passed to the tank through a strainer, which did no more than filter off the coarse detritus. From the tank the water passed down an incline, in an underground pipe, to a ram-chamber situated about thirty-three yards

away. The ram is a pump which raises spring-water from another source for use in the house and other buildings. From information supplied by Mr. Newill, the *Plumatella* is found in the open pool (from which the sample examined was obtained), in the copper strainer at the beginning of the pipe from the pool to the tank, in the same pipe, in the feed-tank, in the pipe leading from the tank to the ram, and in the ram-house. The middle parts of the pipes were said to be less affected than the parts near the tank and the ram. Considerable trouble had been experienced in 1911; and it is expressly pointed out that the Polyzoan ceases to grow about August. In May 1912, when I received the sample, the Polyzoan was in vigorous growth. The nature of the trouble was of the same kind as at Torquay, and consisted in the choking of the pipes and in the blocking of the ram to such an extent that it ceased to work. Unsuccessful attempts had been made to check the growth by the use of copper sulphate. With the Polyzoan were found multitudes of bright red "worms," of a greenish hue when young and dark red when mature. They are described as being marked by dark bands, as growing to a length of one-half to three-quarters of an inch, and of having the habit of changing their skins, "which float on the water." From these indications there is a high probability that the animals in question were Dipterous larvæ, probably of some species of *Chironomus*, as in the case of the Diptera found at Torquay.

Mr. Newill informs me that sand-filters will be installed in the spring of the present year.

### (3) BATLEY.

The first intimation of trouble at Batley was received from the Director of the Royal Botanic Gardens, Kew; but I later obtained samples from Mr. J. C. Barrowclough, the Waterworks Engineer at Batley, who kindly gave me information on the subject. The Polyzoa sent belonged to *Fredericella sultana*, and they had been responsible for trouble of the usual kind—namely, blocking of the meters, strainers, etc. In the sample examined the meter had been fixed on Aug. 19, 1912, and was removed on Oct. 16 completely choked by branches of the *Fredericella*. The supply of these waterworks is obtained from a moorland gathering ground on the Pennine Chain, "having large impounding reservoirs, but no form of filters." The trouble had been known to exist for a long time, but it had been ascribed to peat and other deposits. An examination of the trunk-main had recently been made on account of its reduced capacity through incrustation. The large quantity of iron-compounds found in a dry sample of this incrustation points to the presence of Iron-Bacteria, though no certain evidence of their presence was discovered. It is stated by Mr. Barrowclough that the autumn is the time when special trouble is experienced. As in the other

cases, this is no doubt due to the fact that that time of year is the period at which the tubes of Polyzoa naturally disintegrate, with the result that branches are set free and choke the meters.

(4)

At the end of October 1912 I received, through Mr. S. C. Chapman, a sample from an English waterworks installation, the locality of which I am not permitted to mention. It consisted, in the main, of a mass of tubes of *Paludicella articulata*. The polypides had already disappeared owing to the lateness of the season; but the sample was a particularly beautiful specimen, covered with a profusion of hibernacula or winter-buds, which were developed on every branch. Among the branches of the *Paludicella* there were disintegrated fragments of *Fredericella sultana*. Mr. Chapman informs me that serious trouble had been experienced for some time at the locality in question, although the nature of the organisms causing it had not been recognized.

(5) ABERDEEN.

At the end of March, in the present year, I received a sample, very similar to the last one, from the Aberdeen Waterworks, again through the kindness of Mr. Chapman. This consisted principally of a tangled mass of *Paludicella articulata*, composed of empty zoecia bearing numerous hibernacula. The sample also included a few pieces of *Spongilla lacustris* (determined by Mr. R. Kirkpatrick), crowded with gemmules, a few young specimens of *Limnea peregra* (determined by Mr. G. C. Robson), and some Dipterous larvæ. These were referred by Mr. F. W. Edwards to a species of *Chironomus*, which was, however, not the same as the species found at Torquay. There were also a number of tubes, formed of cemented mud, which appear to have belonged to the *Chironomus*-larvæ.

The following case may also be mentioned, because, although not illustrating the occurrence of Polyzoa in waterworks, it has an obvious bearing on the importance of filtration :—

(6) HAMPTON-ON-THAMES.

On May 22, 1912, 'The Daily Mail' published a short account of the occurrence of enormous numbers of "freshwater mussels" in a 36-inch water main at Hampton-on-Thames. It was stated that 90 tons of these animals had been removed from a length of a quarter of a mile of this main, the diameter of which had been reduced by them from 36 inches to 9 inches. The "mussels" were examined by Mr. G. C. Robson, who found them to belong to *Dreissensia polymorpha*, a Lamellibranch which has been recorded in the pipes of the Hamburg water-supply and elsewhere. Mr. H. B. W. Stent, A.M.Inst.C.E., the Resident Engineer of

the Metropolitan Water Board, has kindly given me some additional information with regard to this case. Without certifying the exactness of the above recorded computation of the weight of the Molluscs removed, he admits the existence of large numbers of these animals in the main. He emphasizes the fact, however, that no trouble of this kind has been experienced in the water which has been admitted to the pipes after filtration. The Molluscs are found only in the mains which are used for conveying water from the Thames to the storage reservoirs, or from the reservoirs to the filter-beds. The importance of filtering the water before admitting it to the pipes is admirably brought out by this case, since the Molluscs in question have been unable to get past the barrier of the filter-beds.

The consideration of the above cases is sufficient to show that the risks which might be caused by the entry of animal life into the pipes of a water-system are not confined to any particular part of the country. The cases which I have examined come from Aberdeen in the north to Torquay in the south-west. It is obvious that if the water is unfiltered and thus contains microscopic organisms in sufficient quantity, the chance introduction of a few Polyzoan statoblasts or embryos might be followed by a growth in the pipes sufficient to interfere very seriously with the circulation, and ultimately to choke the taps. It is important to notice, as has been so well shown by Kraepelin, that the Polyzoa play a leading part in promoting the growth of animal life in the pipes. They are specially adapted by the disposition of their ciliated tentacles to catch the diatoms and other microscopic organisms on which they habitually feed, or, as Kemna \* has expressed it, they are "microphagous." They serve in their turn as the food of larger animals; and, unless they prepared the food in this way, it is hardly likely that animals such as Eels would be capable of flourishing in the pipes of a water-system. The great quantity of Polyzoa found at Hamburg, Torquay, and elsewhere justifies the conclusion that in any discussion of this question the occurrence of Polyzoa is a fact of cardinal importance. Sponges are perhaps the organisms which rank next in importance to the Polyzoa in this respect.

The practical and theoretical interest of this subject has received very little attention in this country. Professor S. J. Hickson, in his Presidential Address to Section D of the Southport Meeting of the British Association (04, p. 675), has, however, used words to which I can completely subscribe. He states "that our ignorance of the general balance of animal and vegetable life in the large reservoirs is profound, and that a systematic inquiry conducted by competent persons would most certainly lead to knowledge which would be of great scientific importance, and in the long run remunerative to the community."

\* Kemna, A., "*Octacnemus*, Une Ascidie mégophage," Ann. Soc. roy. Zool. et Malacol. de Belgique, xli. 1906, p. 57.



It is a curious coincidence that, at the same Meeting of the British Association at which Professor Hickson's address was delivered, the Presidential Address of Mr. Charles Hawksley to Section G (Engineering) dealt specially with water-supply and the construction of waterworks. In this address it is stated (Report, p. 767) that "most waters obtained from gathering grounds are much improved by filtration"; and the mode of construction of sand-filters is indicated. But there is no reference to the importance of the filter as a means of depriving the water of the microscopic organisms which would otherwise supply nourishment to Polyzoa and other "microphagous" animals capable of flourishing in the pipes if they are supplied with appropriate food in sufficient quantity.

I am indebted to Mr. S. C. Chapman for having put at my disposal the result of an extensive enquiry which he has made as to the occurrence of Polyzoa and other animals in the waterworks of this country. As he proposes to publish the result of his enquiries I will not attempt to anticipate him; but he returns show that organisms of the kind indicated occur more frequently than has generally been supposed, and that the occurrence of trouble due to their presence can usually be traced to the want of an efficient system of filtration.

### III. Species of Polyzoa found in British Waterworks.

The species of Polyzoa which I have had the opportunity of examining may be referred to the following four species:—

- (1) *Paludicella articulata* Ehrb.
- (2) *Fredericella sultana* Blumenbach.
- (3) *Plumatella fungosa* Pall., var. *coralloides* Allman.
- (4) *Plumatella emarginata* Allman, var. *muscosa*, Kraepelin.

I subjoin a few notes on the synonymy of the species and on the specimens which form the subject of this paper.

- (1) *PALUDICELLA ARTICULATA* Ehrb. (Pl. LXII. figs. 1-10.)

*Alcyonella articulata* Ehrenberg, "Symbolæ Physicæ," "Animalia Evertibrata," Dec. I., "Phytozoa Polypi," 1831, fol. a.

*Paludicella Ehrenbergii* Dumortier & Van Beneden, "Hist. Nat. des Pol. Comp. d'eau douce," ii. Partie, Nouv. Mém. Acad. Bruxelles, xvi. 1843, p. 38.

Although Allman, in his classical monograph (56) on the Freshwater Polyzoa, accepted the specific name *ehrenbergii*—and has been followed in this respect by many other writers—the reasons given by Dumortier and Van Beneden for rejecting Ehrenberg's name are not in accordance with modern principles of zoological nomenclature. They state as their motive for introducing a new name that "*articulata*" refers to a generic character, and therefore cannot be used as a specific name. The invalidity

of this argument has not escaped the notice of some other writers.

The first specimens examined were received from a waterworks system (No. 4, above), which does not permit itself to be mentioned by name, at the end of October 1912. They were remarkable for the extraordinary freedom with which hibernacula were developed. In correlation with the lateness of the season, the polypides had degenerated, and the zoëcia were represented merely by their empty ectocyst. Nearly every zoëcium, throughout the whole of the material, bears one or two hibernacula in the place of the ordinary lateral daughter-zoëcia; and, if it happens to be at the end of a branch, a terminal hibernaculum as well. These hibernacula (Pl. LXII. figs. 1-10) are, almost without exception, of an elongated fusiform shape, although varying much in length and, to a less extent, in breadth. They thus differ strikingly from most of the figures of these structures which have previously been published.

The hibernacula were originally described, under the name of "hybernacles," by Dumortier and Van Beneden, in the memoir cited above (p. 51, pl. i. fig. 1"; pl. ii. figs. 24-35). Although shown as replacing lateral buds, and therefore in the same position as in the specimens which have come under my notice, they are described and figured as short bodies, not more than about one-fifth of the length of the zoëcia. They are pointed at their free end, and were said to be always strongly compressed. In colour they were greyish black.

Kraepelin, who states (87, p. 76) that the hibernacula do not appear to have been found by any observer since Van Beneden, describes and figures them (pl. iv. fig. 117) as swollen and ellipsoid or irregular, and states that they are yellowish in colour, and that they have a considerable amount of calcareous matter in their cuticle. Several of the specimens figured by Kraepelin resemble the hibernacula described by Van Beneden in their form, but one or two of them are fusiform, although not so elongated as most of the hibernacula which have come under my own observation. Some of them remain attached to the substratum when the zoëcia, which have meanwhile lost their contents, disintegrate and break up. In the second part of his monograph (92, p. 61) Kraepelin refers to the irregular form generally possessed by the hibernacula. He describes the occurrence in them of an elongated polypide-bud (pl. v. fig. 163), which is formed early in their development, in readiness for germination in the ensuing spring; and he mentions the yolk-like material by which the polypide-bud is surrounded. He was unable to discover the mode of formation of the hibernacula.

Levinson (94, p. 85, pl. viii. figs. 24-26) gives figures of the hibernacula which are much like those of Kraepelin.

Wesenberg-Lund (96, pp. 321, 363, xxiv; pl. iv, figs. 44, 45) found the hibernacula in large numbers in October. They were all of the same form and colour as in Kraepelin's description,

and were attached to the substratum, none being discovered on the erect shoots. Their mode of development was not ascertained.

Chirica (04, pp. 7, 8, sep.) does not describe the development of the hibernacula, but records one or two interesting observations. He obtained them, not only at the beginning of the winter, but also attached to branches of dead zoecia, floating at the surface of the water in April, and he regards this as the means by which the species is distributed in the spring. He adds that colonies which have resulted from the germination of hibernacula develop ovaries and testes at once (*cf.* also Kraepelin, 87, p. 86).

The hibernacula of the material examined by myself are, as a rule, very different in form from those which have been described by Dumortier and Van Beneden, Kraepelin, Levinsen, and Wesenberg-Lund. Although varying much in their proportions, the great majority have an elongated fusiform shape, as shown in the figures on Pl. LXII. It does not, however, seem to me necessary to conclude that there is any specific difference between the form examined by me and those of which hibernacula have previously been described. Although *Paludicella* is a light-shunning organism (Allman, 56, pp. 114, 115), these specimens, obtained from the interior of the pipes of a waterworks system, must have been growing in absolute darkness, and under conditions which were otherwise different from the normal habitat of the species. It would thus not be surprising if the hibernacula were found to show some differences from those growing in a normal environment. The conclusion that the specimens under consideration should be referred to *P. articulata* is confirmed by the fact that a single branch observed bore two hibernacula (one of them shown in fig. 1) which have the form described by Dumortier and Van Beneden.

It remains to be seen, however, whether the hibernacula usually developed by *Paludicella* in this country are typically spindle-shaped or not. Mr. C. F. Rousselet has kindly allowed me to examine specimens of hibernacula, collected in Norfolk by Mr. H. E. Hurrell, in his own collection. These hibernacula are all of the general form described below, although they are on the average rather less elongated than the specimens which have come under my own observation. Some of them have germinated, in the manner described by Dumortier and Van Beneden and by Kraepelin. The distal end of the hibernaculum splits into two valves, in order to allow of the escape of the tissues of the young zoecium which grows out of the hibernaculum. It is of some interest to notice, in connexion with what is said below, that the stalk of the hibernaculum remains unsplit during the process of germination.

Mr. Rousselet informs me that he has never seen hibernacula of any other form than the spindle-shape here described.

The hibernacula observed by me are white in colour, although some of them show signs of becoming darker. The material was

obtained towards the end of October, and therefore soon after the hibernacula had been formed. It is not improbable that they would all have become darker as the season progressed. All were growing on erect branches of the colony, and most of them were quite free, although some show the habit which has been described by other observers of attaching themselves to foreign objects; in this case zoecia, or even other hibernacula, of the *Paludicella* itself, or zoecia of the *Fredericella* with which the species was associated. Allusion has already been made to the fact that one, two, or even three hibernacula are borne on nearly every zoecium. They vary much in length and to a less extent in breadth. Leaving out of account the two hibernacula of which one is shown in fig. 1, they are nearly all spindle-shaped, although occasionally showing some irregularity of form, and vary in length from  $608\mu$  (fig. 4) to about  $1968\mu$ . They are usually pointed at their free end, the broadest part being as a rule beyond the middle of their length. The proximal stalk-like portion is generally slender, but varies in breadth from about  $72\mu$  to  $96\mu$ . Measured at their widest part, the width varies from  $144\mu$  to  $160\mu$ . They are usually developed in the position occupied by either the lateral or the terminal daughter-zoecia; but, as shown in fig. 7, the hibernaculum may originate more proximally than the position normally occupied by a lateral bud; and the bases of the lateral hibernacula are not always opposite one another (fig. 8). Most of the hibernacula contain an elongated polypide-bud, in agreement with Kraepelin's statement (92), of the form which also occurs in the development of the polypide-buds of ordinary zoecia. I have not observed any calcareous matter in their wall.

It has often been suggested that the statoblasts of *Phylolactemata* may have been evolved from structures like the hibernacula of *Paludicella* (cf. Kraepelin, 87, pp. 163, 167; 92, p. 62). But while the mode of origin of the statoblasts, from the funiculus, is well understood in its general outlines, I have not been able to discover any account of the development of the hibernacula. The material at present under discussion enables me to make a contribution to this subject, although the facts could have been interpreted with more certainty if the specimens had been collected slightly earlier in the year. There is, however, enough evidence to show that the hibernaculum is not a modified terminal zoecium, as is assumed by Braem (90, p. 112) in criticizing Kraepelin's opinion, but is something which is left when the distal part of a zoecium has been thrown off. The evidence of figs. 2, 3, 9, 10 seems to be unmistakable on this point. In these cases the hibernaculum is well formed, with its thick cuticle and inclusions of yolk-like material. But although its stalk appears to be constituted, in some cases at least, by the proximal part of the zoecium, the distal end of the hibernaculum lies freely in the cavity of the zoecium, which is prolonged in its normal form beyond it. The interpretation which naturally suggests itself is

that the formation of the hibernaculum is inaugurated by a contraction of the endocyst or body-wall from the original ectocyst of the zoëcium, in the distal part at least, and by the deposition of a new cuticle over that part of the hibernaculum which lies freely inside the old ectocyst. In some cases, as in fig. 10, the hibernaculum has a wall of its own which is distinct throughout from the original ectocyst. In the specimen shown in fig. 2 a single zoëcium has developed two hibernacula, the first of which is attached to the parent-zoëcium in the position of a terminal bud, while the second, or distal hibernaculum, lies freely in the cavity and has no base of attachment. It can hardly be doubted that the hibernacula represented in figs. 3, 9, and 10 would have assumed the appearance shown by most of the hibernacula in this material by the loss of the empty caps formed by the zoëcia within which they have severally been developed. I regard it, therefore, as probable that the hibernaculum owes its terminal position to the loss of the distal part of its own zoëcium, which, as shown in fig. 10, is not necessarily the terminal individual of a branch.

There are, however, certain appearances, shown in figs. 6-9, that are in need of explanation. In these cases most of the ectocyst of the zoëcium which precedes the definitive hibernaculum has split into two valves, in the manner characteristic of a germinating hibernaculum. Like the other zoëcia of this material, these zoëcia are destitute of cellular contents; the only living tissues left in the colonies being those which constitute the hibernacula. It is important to consider whether the bivalve arrangement indicates that a process of germination has actually taken place. In view of the close resemblance between these zoëcia and a hibernaculum germinating after the end of the winter and arrived at the stage of having completed the formation of the first regenerated zoëcium, it seems legitimate to assume that germination of a hibernaculum has occurred in spite of the fact that the material was collected in the autumn. It would appear that a new zoëcium has been completely formed, since the remains of its tubular orifice are present. But the development of a new colony has stopped short with the formation of a single zoëcium, and a second process of hibernaculum-development has taken place, resulting in the definitive winter-buds. The living material of the regenerated zoëcium has passed into the hibernaculum, or hibernacula, which have been formed from it, though there is no evidence to show whether the transference of the material took place *en masse* or by the more gradual process by which a bud is ordinarily supplied with its living contents. It is perhaps not impossible that no polypide was formed by the regenerated zoëcium, but that on the splitting of the hibernaculum which preceded it the contents of that structure passed bodily into the newly-formed hibernaculum. Some such transference of cellular material may be indicated by fig. 10, where each of the hibernacula is seen to traverse the septum which

occurs between two zoëcia. In fig. 8 the definitive hibernaculum may be proved by measurement to be of exactly the same length as the hibernaculum which is indicated by the split valves in the wall of the preceding zoëcium. The material of the first hibernaculum would thus just fill the cavity of the second one. In fig. 9, however, the second hibernaculum is distinctly smaller than the first one; while in fig. 7, what is assumed to have been the first hibernaculum has had to provide the material for two new hibernacula. Further observations on material collected at a more favourable season will be required to settle these points.

The great majority of the zoëcia in a *Paludicella*-colony give rise to a pair of lateral buds, situated opposite one another and in a position which has a definite relation to the orifice of the parent-zoëcium. It may be significant that in all the cases shown in figs. 6-9 there is some abnormality in this respect. In figs. 6 and 9 only one of the lateral zoëcia is indicated; while in figs. 7 and 8, where two are present, they are not opposite one another, and in fig. 7 one of them is much nearer the proximal end of the parent-zoëcium than is normally the case. I have observed similar irregularities in other zoëcia of the same kind which have not been figured; and these cases perhaps support the view that germination of the hibernacula first formed has taken place, since it is well known that in young Polyzoon colonies the zoëcia first developed frequently fail to give rise to the full number of buds which are formed by the zoëcia in an actively growing branch.

If the explanation above suggested is correct, the germination of the first set of hibernacula may perhaps have been induced by the occurrence of warm weather succeeding a cold period, which induced the formation of the first set. But the explanation in question is not the only one which can be imagined; and it is not inconceivable that as the time of hibernaculum-formation approaches, some of the zoëcia make an abortive attempt to develop hibernacula, and that the bivalve arrangement seen in figs. 6-9 implies an unsuccessful effort of this nature.

In the majority of the zoëcia of this material the definitive hibernacula have been produced at the first attempt, and the zoëcia which respectively precede them show no appearance of a bivalved arrangement. But in all cases the zoëcia are empty of cellular contents, and there has obviously been a centrifugal passage of the living material of the colonies into the hibernacula, which are finally left as the outermost members of the series.

It remains to be considered whether these observations have any bearing on the question of the homology, if any correspondence really exists, between the hibernacula of *Paludicella* and the statoblasts of Phylactolæmata. It has frequently been maintained that statoblasts have been evolved from structures more or less resembling the hibernacula of *Paludicella*, which on this view is regarded as related to the ancestral form from which the Phylactolæmata have been derived. This argument has been specially developed by Kraepelin (87, pp. 163, 167; 92, p. 62),

who based his conclusions on the general similarity of the hibernacula to statoblasts, particularly those of *Fredericella* in which no annulus is present. He did not, however, bring forward any evidence to show how the hibernacula are developed. Braem (90, p. 112) has disputed Kraepelin's conclusions, basing his objection largely on the assumption that the hibernacula are complete, specially modified, terminal individuals of the colony. On this assumption there would be a considerable difference between them and the statoblasts, which are essentially buds produced internally within the body-cavity of a zoecium. Braem's objection loses some of its force if his assumption as to their mode of origin can be shown to be incorrect. I think that the evidence here brought forward is sufficient to render the conclusion that the hibernaculum is typically an end-bud of the colony very doubtful. Although the proximal part of its ectocyst is commonly a modification of the corresponding part of the ectocyst of the parent-zoecium, cases like those shown in figs. 2 and 10 appear to prove that the hibernaculum may be formed as an internal bud-like structure, with a complete cuticle of its own; and there is indeed no very essential difference between the proximal hibernaculum shown in fig. 10 and the statoblast of a *Fredericella*. I do not, of course, overlook the fact that the statoblasts of Phylactolamata are developed in a peculiar way from the funiculus of a polypide. But *Paludicella* is, in any case, only distantly related to the Phylactolamata; and the difference between the winter-buds of the two forms is not, apparently, so great as has hitherto been assumed by most observers who have considered the question.

When one considers the facility with which freshwater organisms, from Protozoa upwards, develop some special cyst-like coat which enables them to survive the winter or periods of drought, one must no doubt be cautious in assuming that the homology suggested is a probable one. But my observations seem to show that the hibernaculum of *Paludicella*, like the statoblasts of Phylactolamata, is a special form of winter-bud which is developed inside the parent zoecium out of a mass of living tissue which becomes surrounded by a chitinous coat; and that thus the two kinds of winter-buds are morphologically comparable. In view of this consideration it does not appear to me impossible that the hibernaculum and the statoblast represent two different conditions which have been evolved from a common starting-point.

The specimens of this species received from Aberdeen (No. 5, above) agree closely with those just described. Numerous hibernacula of an elongated type are present, although they are perhaps more variable in length than in the other sample. Some of them are even longer than the longest described above.

*Paludicella articulata* has previously been recorded as an inhabitant of the pipes of waterworks, both at Hamburg (Kraepelin, 85, p. 6) and at Rotterdam (De Vries, 90, p. 25).

(2) *FREDERICELLA SULTANA* Blumenbach. (Pl. LXIII. figs. 11-14.)

It is unnecessary for me to discuss the synonymy of this species, since there is a general agreement with regard to it among practically all recent writers. Excellent accounts of the species are given by Allman (56), Kraepelin (87), and many others. It was recorded by Kraepelin (85, p. 6) as one of the commonest forms found in the Hamburg Waterworks system; and I suspect that one of the species of "*Plumatella*" recorded by De Vries (90) from the Rotterdam Waterworks may have been really *Fredericella*.

I have myself found *F. sultana* in two English waterworks; namely the system (No. 4) in which the *Paludicella* above described occurred and at Batley. In both cases the material was collected in October, and the polypides had already degenerated, leaving empty tubes containing statoblasts. The tubes show the septa which have been described by Allman (56, p. 112), Kraepelin (87, p. 100), and others, at the point where a tube diverges from the main stem. The statoblasts are developed in both localities with greater profusion than is sometimes the case in this species. Kraepelin has commented (pp. 103, 104) on the variability of the statoblasts of *F. sultana*. He states that it is hardly possible to find two alike in the same colony; and that they may be reniform, almost quadrangular, or even nearly circular. The average length is given by him as  $430\ \mu$ , and the average breadth as  $300\ \mu$ . The length varies between  $380\ \mu$  and  $570\ \mu$ ; and the breadth between  $210\ \mu$  and  $370\ \mu$ .

Figs. 11-14, taken from the Batley material, show that my own results are in close agreement with Kraepelin's. The variation in form is sufficiently obvious from these figures. The average length of nine statoblasts from Batley was  $444\ \mu$ , a measurement almost identical with Kraepelin's. The extreme measurements were  $416\ \mu$  and  $480\ \mu$ . The average breadth of the same nine specimens was  $242\ \mu$ —somewhat less than Kraepelin's figure,—while the extremes were  $200\ \mu$  and  $272\ \mu$ . Some were more than twice as long as broad (fig. 14); while the statoblast shown in fig. 11 is almost circular.

Kraepelin states that the funiculus of *Fredericella* generally gives rise to one or two statoblasts, rarely to three. In my own material, while many of the zoecia contain a single statoblast, and others contain either two or three, one of the tubes in the Batley material contains four statoblasts, which certainly belonged to one polypide. In several instances it can be seen that the statoblasts are closely adherent to one wall of the tube. In cases where two tubes are connate, the statoblasts are adherent to the common wall which separates the two tubes. In the Batley material the statoblasts are almost black in colour, and a large proportion of them, although still contained in the zoecia, have split into their two valves, between which can be seen a mass of living tissue. This is a clear sign that the statoblasts are ready



to germinate. It is well known that the statoblasts in this species ordinarily germinate without leaving the tubes in which they have been produced. It need hardly be pointed out that the state of the winter-buds, here as in the *Paludicella* described above, is such as to give every opportunity for the dispersal of the species throughout the system into which it has effected an entrance. In the Batley case at least (and probably in the other) the branches examined were not taken from the places where they had been growing in the pipes, but had become free by the disintegration of the colonies at the approach of winter, and had accumulated in the meters and taps to such an extent as to block them.

(3) *PLUMATELLA FUNGOSA* Pallas, var. *CORALLOIDES* Allman. (Pl. LXIII. figs. 22-25.)

I follow Braem (90, p. 3) in regarding *Plumatella coralloides* of Allman as a form of *P. fungosa*. This seems to be indicated by Allman's fig. 4 (pl. vii.) of the floating statoblasts. It should, however, be noted that Annandale, in his recent account of the Indian species (11, pp. 217, 218), gives *P. coralloides* as a synonym of *P. fruticosa*.

In dealing with representatives of the genus *Plumatella* one is confronted with numerous difficulties; since there is no general agreement with regard to the species which ought to be recognised. It is worth remembering that *Plumatella* has three different kinds of reproductive bodies, namely, the embryos produced by the development of the eggs, the floating statoblasts, provided with an "annulus" of gas-containing cavities, and the sessile statoblasts. We are in almost complete ignorance with regard to the question whether the form of the colony depends to any extent on the particular kind of reproductive body from which it has been developed. As Braem has pointed out (90, p. 8; 11, p. 9), experimental evidence on this subject is urgently needed; and it is probable that a well-conceived series of breeding experiments carried out with statoblasts and embryos of *Plumatella* might resolve some of the difficulties which at present exist. Braem (90, p. 6) has recorded the important observation that in cases where the remains of the statoblast from which a colony has germinated can be detected at the proximal end of the colony, the form of that statoblast can sometimes be proved to be identical with those which are being produced in the tubes of the same colony. There are reasons for believing, as has been remarked above, in dealing with *Paludicella*, that ovaries and testes are usually produced early in the summer from colonies which have resulted from the germination of statoblasts or hibernacula (*cf.* Kraepelin, 87, p. 85). But it has not been sufficiently ascertained how far, if at all, these sexually mature colonies differ from those produced by statoblasts; nor is it known whether there are any differences between colonies

produced from floating statoblasts and those which have developed from sessile statoblasts.

It is believed by most recent authorities that *Alcyonella* is not generically separable from *Plumatella*. *Alcyonella* is characterised by its compact form, resulting from the arrangement of its crowded, more or less parallel, tubes, more or less at right angles to the substratum. It has been suggested that this habit of growth is largely, if not entirely, the result of the simultaneous germination of a number of statoblasts situated close together. But I am not aware of the existence of any experimental evidence to show whether a large colony of *Alcyonella fungosa* can be produced by the germination of a single statoblast. Some evidence that the completely parallel tubes of the typical *fungosa*-form owe their arrangement to want of room, is given by the fact that the peripheral parts of a *fungosa*-colony may have the form of the var. *coralloides*, which is characterised by a looser habit of growth.

The conclusion that "*Alcyonella*" is merely a form of *Plumatella* seems to me to be well founded. The only generic distinction which can be maintained is the habit of growth; and in this character *P. fungosa* var. *coralloides* is intermediate between "*Alcyonella*" and *Plumatella*. Kraepelin (87) has gone so far as to regard *P. fungosa* as merely a form of *P. repens*, which is termed by him, on insufficient nomenclatorial grounds, *P. polymorpha*. In this conclusion he was at one time criticised by Braem (90), who pointed out differences which led him to believe that *P. fungosa* is specifically distinct from *P. repens*. Braem has more recently (11, p. 9) retracted this view, and he now regards *P. repens* and *P. fungosa* as varieties of one species.

The specimens which may be referred to the *P. fungosa* type were sent on May 31, and were received alive, with their polypides in full vigour. As has been pointed out above, they were taken from the pool which supplies the system, and I have not seen specimens from the pipes themselves, where great trouble has been caused. Mr. R. H. Newill, to whose kindness I owe the specimens and as much information as he was able to give, has, however, assured me that the specimens which blocked the pipes and ram resembled those which had been taken from the pool supplying the system. There is thus a strong presumption that the specimens examined belonged to the same species as those which occurred in the pipes; a conclusion which is rendered all the more probable by the fact that this form has a very characteristic habit of growth, which Mr. Newill cannot have failed to notice.

I have had some difficulty in deciding whether the specimens in question should be regarded as typical examples of *P. fungosa* or should be referred to its variety *coralloides* (= *Plumatella coralloides* Allman, cf. Allman, 56, p. 105). In the more central parts of the masses the tubes have the *fungosa*-arrangement. In the more peripheral parts of the material they may be less

intimately connected with one another, and are therefore like the form which has been described as var. *coralloides*.

Braem (90, p. 4) has stated that the floating statoblasts of *P. fungosa* (typical form) have an average length of  $410\ \mu$ , and an average breadth of  $320\ \mu$ ; the corresponding measurements for var. *coralloides* being respectively  $380\ \mu$  and  $300\ \mu$ . In my own material the average length of eleven floating statoblasts, in one series of measurements, was  $371\ \mu$ ; and the average breadth was  $240\ \mu$ . The extreme measurements were:—Length,  $328\ \mu$  and  $416\ \mu$ ; breadth,  $224\ \mu$  and  $264\ \mu$ . In another series of measurements, in which the statoblasts of the compactly arranged tubes were distinguished from those of the peripheral, more *coralloides*-like tubes, the average length was  $388\ \mu$  and the average breadth rather more than  $280\ \mu^*$  for the former; while for the latter the length was  $358\ \mu$  and the breadth was  $266\ \mu$ . There is thus some difference between the sizes of the statoblasts in different parts of the same mass of tubes: the loosely arranged zoecia at the periphery having somewhat smaller statoblasts than the more centrally placed ones. But even the largest statoblasts agree more closely in size with those of var. *coralloides* (from Braem's measurements) than with those of the typical *fungosa*-form (as given by the same author). I refer the specimens, therefore, to var. *coralloides*; and this conclusion is confirmed by the measurements which I have made of a very typical *fungosa*-form from a pond at Upper Norwood (Brit. Mus. 85.7.28.5–8), in which the average length of the floating statoblasts was  $431\ \mu$ , and the average breadth  $307\ \mu$ : in close agreement with Braem's figures.

The floating statoblasts of the material from Styche have the form shown in fig. 22. They do not vary much in form, although in some of them one of the sides is more convex than the other. The annulus leaves a considerable part of the central capsule exposed on both surfaces of the statoblast. The average ratio of length to breadth (11 cases) is 1.543 : 1.

The sessile statoblasts are considerably larger than the floating statoblasts. On the attached surface (fig. 23) the central capsule gives off an irregular peripheral ring of cementing substance, which forms a vertical ridge by which the statoblast is fixed to the wall of the tube in which it has been produced. On the free surface (fig. 25), a saucer-like shape is produced by the development of a thin marginal collar. This represents the annulus of the floating statoblasts, as is shown by its structure.

In some statoblasts the gas-cells are represented by only a small proportion of the number found in a floating statoblast; and these occur in isolated groups, of irregular and obviously inconstant form (fig. 25). In other cases, as in fig. 24, the annulus forms a complete band, which is almost as well developed as in the floating statoblasts.

\* The uncertainty about the breadth is due to the fact that the statoblasts measured were not resting accurately on one of their flatter surfaces.

The sessile statoblasts are very variable in shape and size (figs. 23-25), but they are all larger than the floating statoblasts of the same specimens. The largest one found measured  $640\ \mu$  by  $432\ \mu$ , giving a ratio of  $1.481:1$ . A shorter and broader one was  $560\ \mu$  by  $480\ \mu$ , with a ratio of  $1.166:1$ . The average of seven measurements was  $554\ \mu$  by  $434\ \mu$ , with a ratio of  $1.276:1$ .

(4) *PLUMATELLA EMARGINATA* Allman, var. *MUSCOSA* Kraepelin. (Pl. LXIII. figs. 15-20.)

In his well-known work on the German Freshwater Polyzoa, Kraepelin (87) refers the forms of *Plumatella* which have come under his observation to three species. These are described respectively as *P. princeps*, *P. polymorpha*, and *P. punctata*. For the last, with which it is not necessary for me to deal, he has adopted Hancock's name. The first two were renamed by him, on the ground (pp. 118, 119) that the older names, from which a choice might have been made, have been used in so many different senses by previous authors that it would only have introduced additional confusion to have made use of any of them for the species as characterised by him. I do not think it necessary to follow Kraepelin in this conclusion.

*P. princeps* and *P. polymorpha* were distinguished principally by the form of the floating statoblasts. In *P. princeps* these are relatively long and narrow, and the ratio of length to breadth is said to vary from  $1.53:1$  to  $2.79:1$ , the typical ratio being given as about  $1.8:1$ . The species thus characterised includes *P. emarginata* Allman and *P. fruticosa* Allman.

In *P. polymorpha* the floating statoblasts are broader in proportion to their length, and the ratio of length to breadth is described as varying from  $1.1:1$  to  $1.42:1$ ; the average being about  $1.25:1$ . Under this name Kraepelin includes *P. repens* and *P. fungosa* anctt.

The forms of *Plumatella* with relatively broad statoblasts are represented in the material which I have received from English waterworks only by a variety of *P. fungosa*, which, following Braem's earlier opinion, I have treated above as a species distinct from *P. repens*. Those with elongated statoblasts are represented by the material from Torquay, and it thus becomes necessary to discuss the question of the name which should be used in describing them.

Braem (90, pp. 9, 10) has brought forward arguments to show that *P. fruticosa* and *P. emarginata* are distinct species; and he points out the following differences between them:—

(1) *P. fruticosa* has relatively slender tubes, which grow into an erect form; while *P. emarginata* has broader tubes, which are more adherent to the substratum. (2) The floating statoblasts of *P. fruticosa* are more than twice as long as broad (average ratio :

length to breadth, 2·497 : 1 \*), while the annulus does not cover so much of the central capsule as in the other species. In *P. emarginata*, on the other hand, the floating statoblasts are less than twice as long as broad (average ratio: length to breadth, 1·868 : 1), while the annulus covers nearly the whole of the "upper" side, leaving only a small portion of the central capsule uncovered. (3) In *P. fruticosa* the sessile statoblasts have a broad vestigial annulus, and are more than twice as long as broad (ratio, 2·461 : 1), while those of *P. emarginata* resemble the sessile statoblasts of *P. repens*, and have no annulus, while they are less than twice as long as broad (ratio, 1·312 : 1).

Through the courtesy of the authorities of the Hamburg Museum, I have had the opportunity of examining specimens of both var. *muscosa* Kraepelin and var. *spongiosa* Kraepelin, from the original material described by that author. I have figured a floating statoblast (fig. 18) and a sessile statoblast (fig. 20) of var. *muscosa*, from the Hamburg material, for comparison with the Torquay specimens. The measurements which I have made of the statoblasts from Hamburg agree closely with those given by Kraepelin, and are as follows:—

	FLOATING STATOBLASTS.			SESSILE STATOBLASTS.		
	Length. μ	Breadth. μ	Average ratio, L : B.	Length. μ	Breadth. μ	Average ratio, L : B.
Var. <i>muscosa</i> ...	432-496	240-280	1·817 : 1	384-592	272-352	1·456 : 1
Var. <i>spongiosa</i> ...	448-480	256	1·833 : 1	416-496	320-384	1·278 : 1

Very few floating statoblasts are present in the *spongiosa*-material, in which there are a number of sexually produced embryos.

If Braem's criticism of Kraepelin's results is correct, it follows from these measurements that both varieties, *muscosa* and *spongiosa*, are to be regarded as forms of *P. emarginata*; and in this I am following what I understand to be Braem's opinion.

The specimens sent from the Torquay Waterworks by Mr. S. C. Chapman appear to me to be referable to *P. emarginata*, as understood by Braem, although their floating statoblasts are less elongated than in the Hamburg specimens. I find that these statoblasts vary in length from 328 μ to 416 μ and in breadth from 224 μ to 264 μ, the average measurements (11 cases) being:—Length, 371 μ; breadth, 240 μ; ratio, L : B, 1·543 : 1.

\* The ratio is calculated from the measurements given by Braem.

The sessile statoblasts have the following measurements:—Length,  $432\mu$ – $448\mu$ , average  $442\mu$ ; breadth,  $320\mu$ – $368\mu$ , average  $336\mu$ ; average ratio, L: B, 1.317:1.

If Braem is right in separating *P. emarginata* and *P. fruticosa*, the proportions of the sessile statoblasts would alone justify the reference of the Torquay specimens to *P. emarginata* rather than to *P. fruticosa*. I am confirmed in the belief that they belong to the former species by the fact that the annulus covers nearly the whole of the central capsule on one surface of the statoblast (figs. 15–17), as shown by Allman (56, pl. vii. fig. 7) in one of his figures, and by Braem (90, pl. i. fig. 12), who has called special attention to the importance of the character in question.

In Kraepelin's series of measurements of the forms regarded by him as belonging to *P. princeps* (87, pp. 112, 113) the average ratio of length to breadth is given as 1.8:1. But he admits a considerable variation in this respect, the limits given being from 2.79:1 to 1.53:1. It will be seen that my own measurement of 1.543:1 falls within these extremes, although it is much nearer Kraepelin's lower figure. The highest ratio of length to breadth measured by me is 1.666:1, and the lowest is 1.333:1. The latter ratio would bring the statoblasts well within the limits given by Kraepelin for his *P. polymorpha*, which includes *P. repens* auctt. It thus becomes necessary to consider whether the Torquay specimens should be referred to *P. repens* instead of to *P. emarginata*.

I have accordingly compared the Torquay statoblasts with the variety of *P. fungosa* described above and with what I regard as a typical form of *P. repens*, obtained at Cringleford, near Norwich. It will be seen from the figures that the floating statoblasts of the Torquay specimens (figs. 15–17) are distinctly longer, in proportion to their breadth, than those of either *P. repens* (fig. 21) or *P. fungosa* var. *coralloides* (fig. 22), and that the annulus covers much more of the central capsule. It will be remarked, moreover, that in the Torquay specimens the annulus extends over the central capsule further on one side than on the other side of the statoblast, in agreement with *P. emarginata* var. *muscosa* (fig. 18, from a Hamburg specimen); while in the other two forms the annulus is about equally developed on both sides. The floating statoblasts of *P. fungosa* (fig. 22) are distinctly larger than those of *P. repens* (fig. 21). I have not obtained sessile statoblasts of *P. repens* for comparison. Kraepelin denies the existence of this form of statoblast in the typical *P. repens*, but Braem (90, p. 6) claims to have found them. In *P. fungosa* the sessile statoblasts (figs. 23–25) are very large, and possess a rather well-developed annulus; while they are smaller, and with a more vestigial annulus, in the specimens of *P. emarginata* var. *muscosa*, both from Hamburg (fig. 20) and from Torquay (fig. 19).

I fully admit that the floating statoblasts of the Torquay specimens are short as compared with those of more typical specimens of *P. emarginata*; but it appears to me that the result

of the above comparison is to support the conclusion that the Torquay material should be referred to that species, and I lay special stress on the unequal development of the annulus on the two sides of the statoblast. Kraepelin's var. *muscosa* was characterised by him as a luxuriantly branched form of *Plumatella* in which the branches were not cemented together (in this respect differing from his var. *spongiosa*\*). The Torquay specimens seem to me to agree closely with those from Hamburg in their mode of growth, and I have accordingly thought it best to refer them to the same variety.

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\* Hartmeyer (09, p. 53) describes Kraepelin's var. *spongiosa* as a distinct species, under the name of *Plumatella spongiosa*.

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## EXPLANATION OF THE PLATES.

## PLATE LXII.

Showing hibernacula of *Paludicella articulata* from the pipes of an English waterworks-system.

The figures were drawn with a Zeiss A objective, and were then reduced two and a half diameters. The scale represents hundredths of a millimetre.

- Fig. 1. Zoecium bearing a hibernaculum of the type described by Dumortier and Van Beneden. (Only two hibernacula of this type were found in the whole of the material examined.)
- Fig. 2. A zoecium, accidentally folded, which has developed two hibernacula, while it bears two other hibernacula (bases shown) in the place of the ordinary lateral buds. The preceding zoecium also bears two lateral hibernacula.
- Fig. 3. Zoecium bearing three hibernacula. The distal one is small, and is still enveloped distally by the remains of the zoecium in which it has been formed.
- Fig. 4. The smallest hibernaculum found. It shows distally the remains of the zoecium in which it was formed. The elongated polypide-bud is seen in its interior.
- Fig. 5. Zoecium with three hibernacula, each of which shows a polypide-bud.
- Fig. 6. Basal view of a zoecium which shows two split hibernaculum-valves in its ectocyst.
- Fig. 7. A similar zoecium, in basal view, with a terminal and a lateral hibernaculum. The latter is developed nearer the proximal end of the zoecium than is usually the case.
- Fig. 8. Side view of a similar zoecium, showing the septa from which lateral zoecia have broken off. A fully-formed hibernaculum is present distally.
- Fig. 9. A similar zoecium, bearing a terminal hibernaculum, which is still enclosed, distally, in the remains of the zoecium inside which it has been formed.
- Fig. 10. A series of three zoecia, with the proximal end of a fourth zoecium. The proximal zoecium has developed a hibernaculum which has passed partly through the terminal septum. The third zoecium bears a terminal hibernaculum, the proximal end of which partly traverses the corresponding septum.



## PLATE LXIII.

Statoblasts of various Phylactokemata (detailed structure of the annulus not represented).

The figures were drawn with a Zeiss C objective, and were then reduced two and a half diameters. The scale represents hundredths of a millimetre.

Figs. 11-14. *Fredericella sultana*, showing the variable form and size of the statoblasts. Batley Waterworks.

Figs. 15-17. *Plumatella emarginata* var. *muscosa*; floating statoblasts. Torquay Waterworks.

Fig. 15. "Ventral" view of a young statoblast. The central capsule is represented by the deeper shading. The line concentric with the outline of the central capsule, and next inside that line, indicates the extension of the annulus on the "ventral" side. The inner circle represents the edge of the annulus on the "dorsal" side, as seen through the central capsule.

Fig. 16. "Ventral" view of an old statoblast. The outline of the central capsule is obscured by the annulus, and is not seen.

Fig. 17. "Dorsal" view of an old statoblast. The annulus covers nearly the whole of this surface of the central capsule.

Fig. 18. *Plumatella emarginata* var. *muscosa*. Hamburg Waterworks (from Professor Kraepelin's material). The annulus covers most of the central capsule on this surface of the statoblast.

Fig. 19. *Plumatella emarginata* var. *muscosa*. Torquay Waterworks. Sessile statoblast, showing the vestigial annulus; from the unattached surface.

Fig. 20. *Plumatella emarginata* var. *muscosa*. Hamburg Waterworks (from Professor Kraepelin's material). Sessile statoblast; from the attached surface.

Fig. 21. *Plumatella repeas*. Floating statoblast; from a pond, communicating with the River Yare, at Cringleford, near Norwich.

Figs. 22-25. *Plumatella fungosa* var. *coralloides*. Styche Waterworks (from the pool supplying the system).

Fig. 22. Floating statoblast.

Fig. 23. Sessile statoblast, from the attached surface; showing the cement-substance by which it is attached to the inner wall of the zoecium.

Fig. 24. Sessile statoblast, with well-developed annulus, the details of which are represented in a small area on the right side of the figure; from the unattached surface.

Fig. 25. Sessile statoblast, with vestigial annulus, which shows remains of the gas-containing cavities (only represented at the upper and left parts of the figure); from the unattached surface.

34. The Marine Fauna of British East Africa and Zanzibar, from Collections made by Cyril Crossland, M.A., B.Sc., F.Z.S., in the Years 1901-1902. Bryozoa \*—Cheilostomata. By ARTHUR WM. WATERS, F.L.S., F.G.S.†

[Received March 13, 1913: Read April 22, 1913.]

(Plates LXIV.-LXXIII.‡ and Text-figures 79-82.)

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The collection made by Mr. Cyril Crossland in the neighbourhood of Zanzibar contains 76 species or varieties of Cheilostomata, and all are from shallow water, in fact with the exception of two are from 10 fathoms or under; so that, for a purely shallow-water collection, it is a very large one.

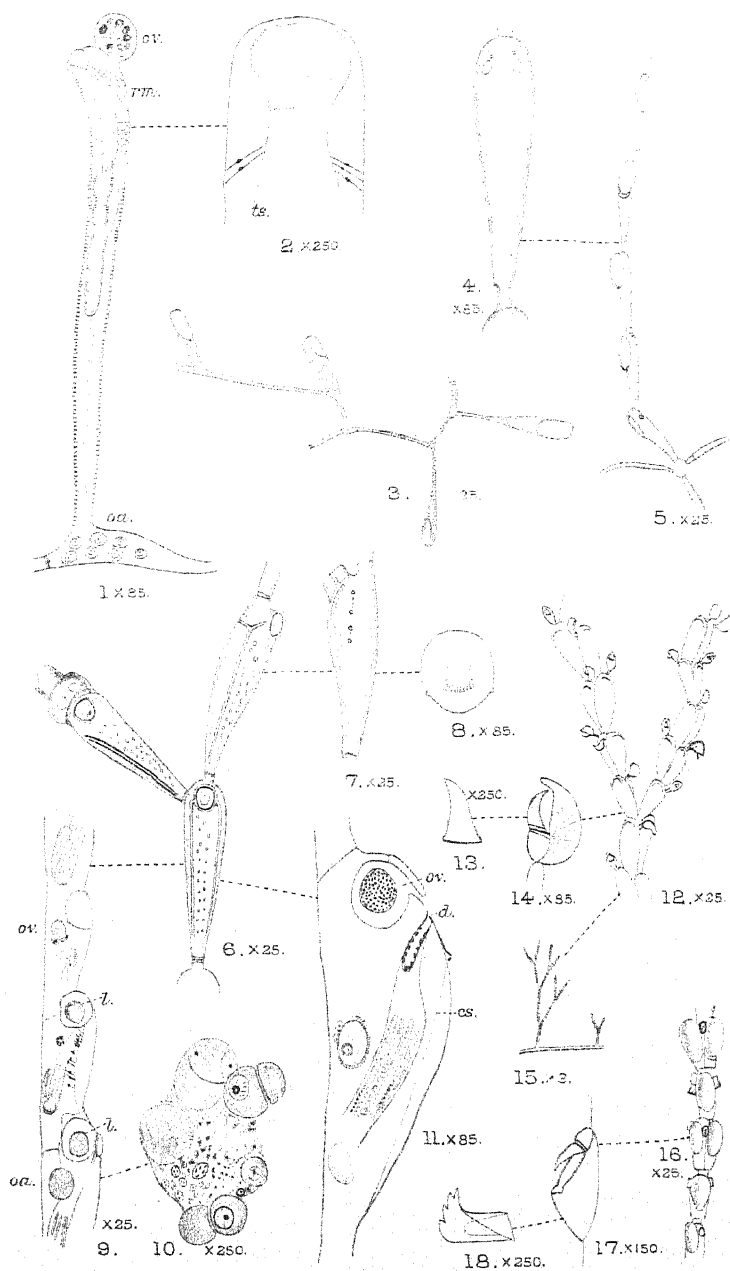
## Points of Special Interest.

- (1) In *Stirparia* the first zoecium of a tuft has the character of a primary zoecium (p. 470).

\* [In view of the difference of opinion as to whether this Phylum should be called Bryozoa or Polyzoa (see Proc. Linn. Soc. 1911, p. 61) I have not interfered with the preference of the author.—EDITOR.]

† Communicated by CYRIL CROSSLAND, M.A., B.Sc., F.Z.S.

‡ For explanation of the Plates, see p. 532.

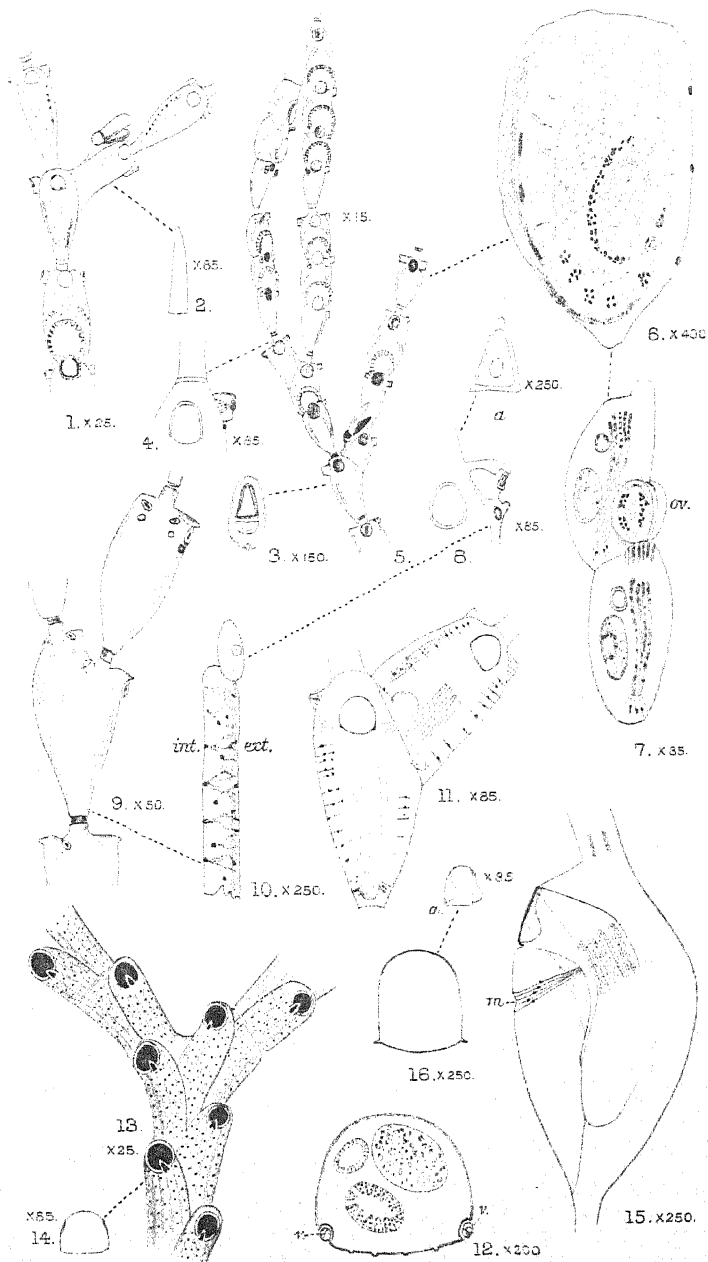


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Hath sc. et imp.

## BRYOZOA FROM ZANZIBAR





A.W. Waters del.

Huth sc et imp.

BRYOZOA FROM ZANZIBAR.



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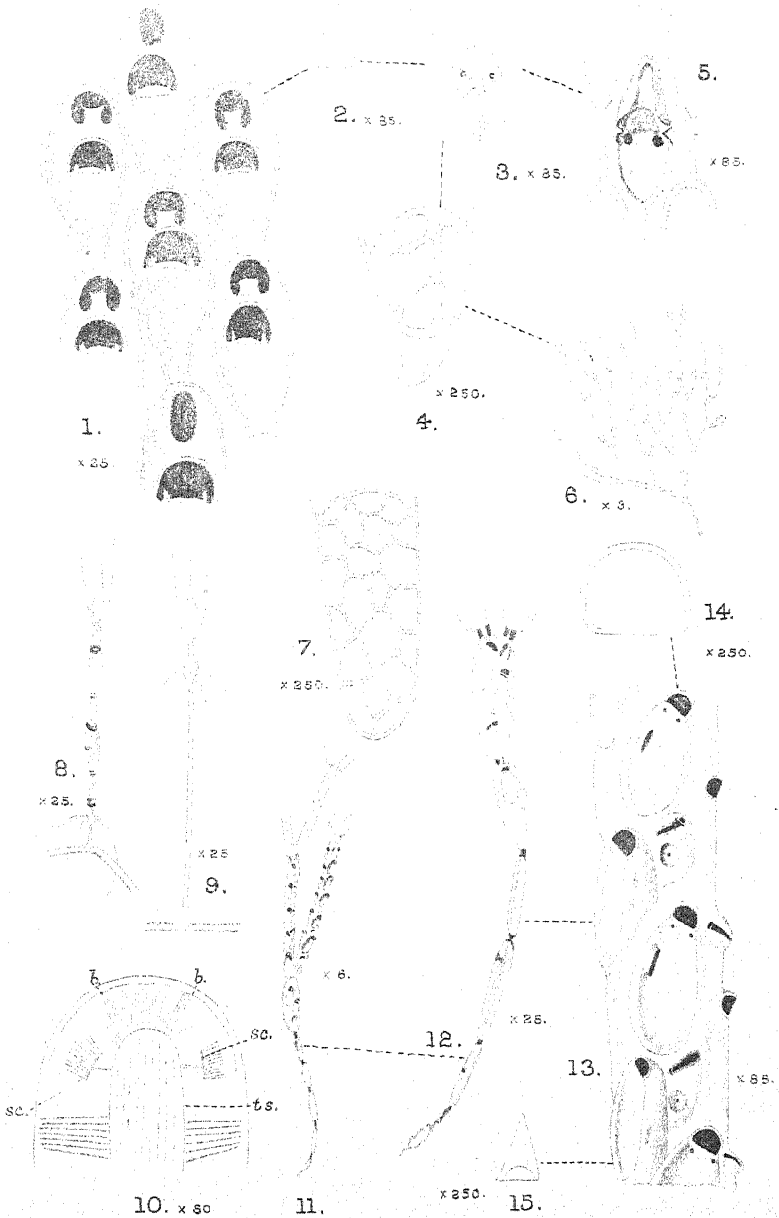
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BRYOZOA FROM ZANZIBAR.





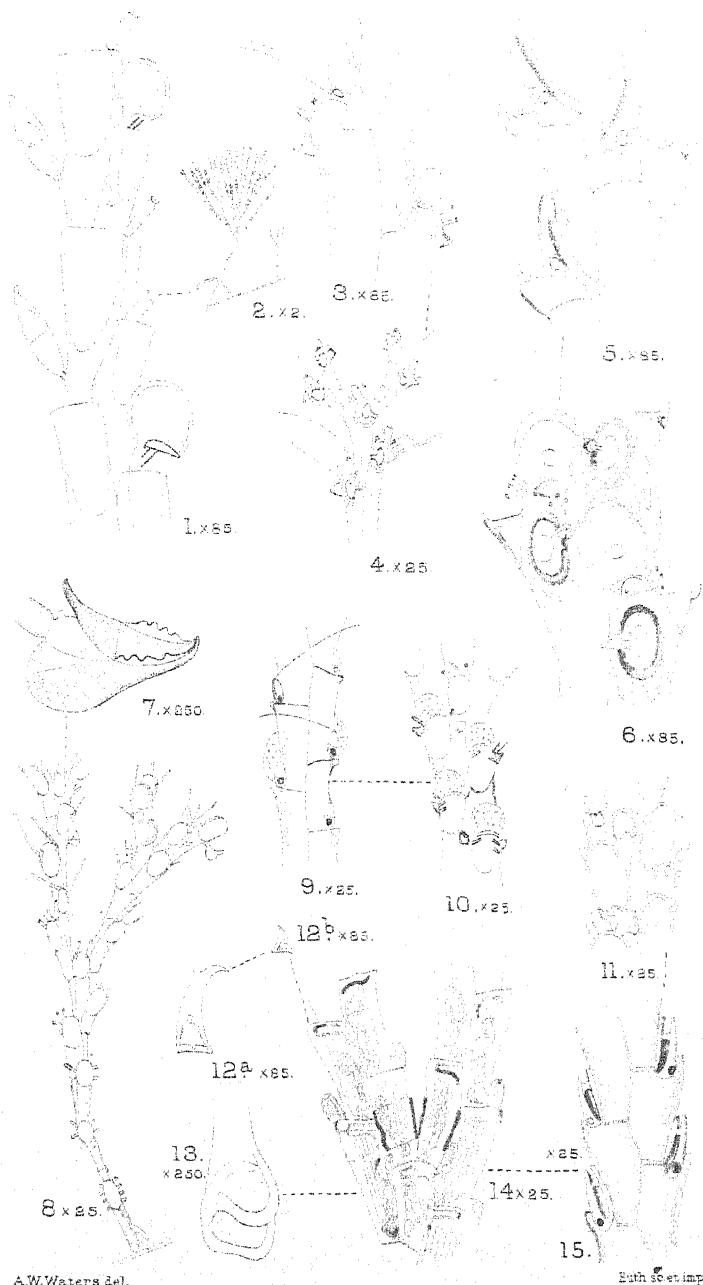


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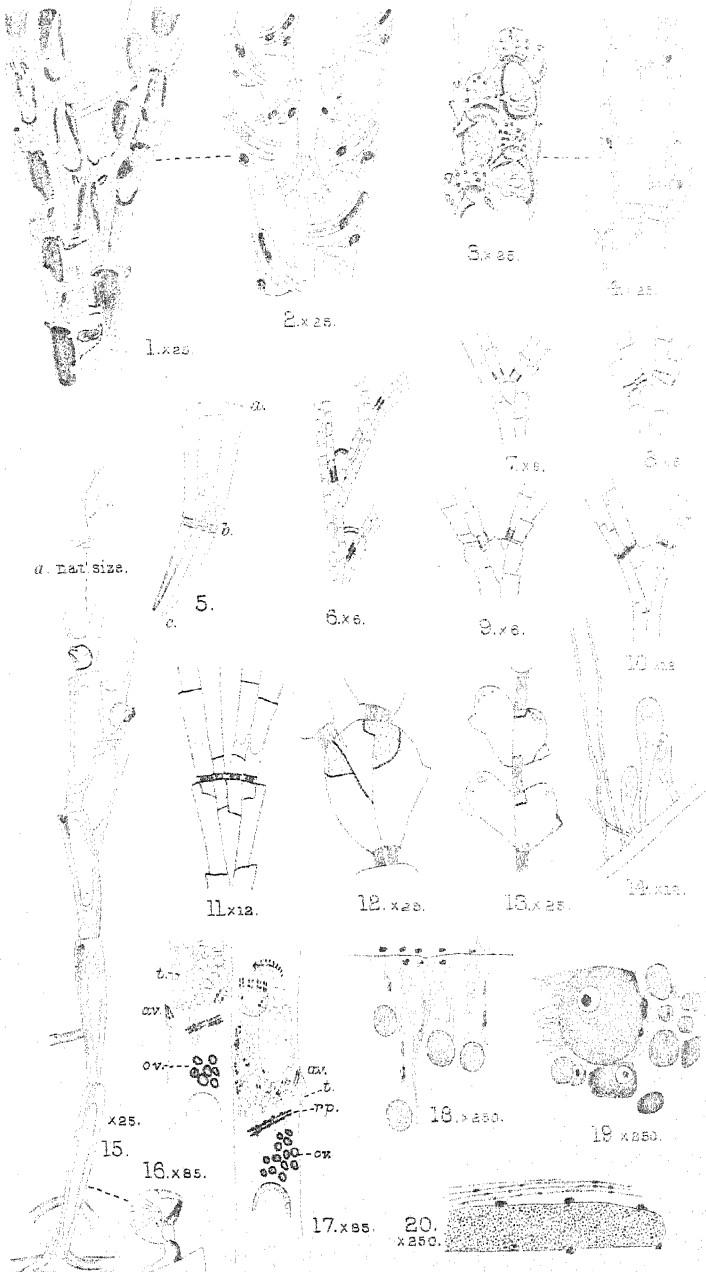




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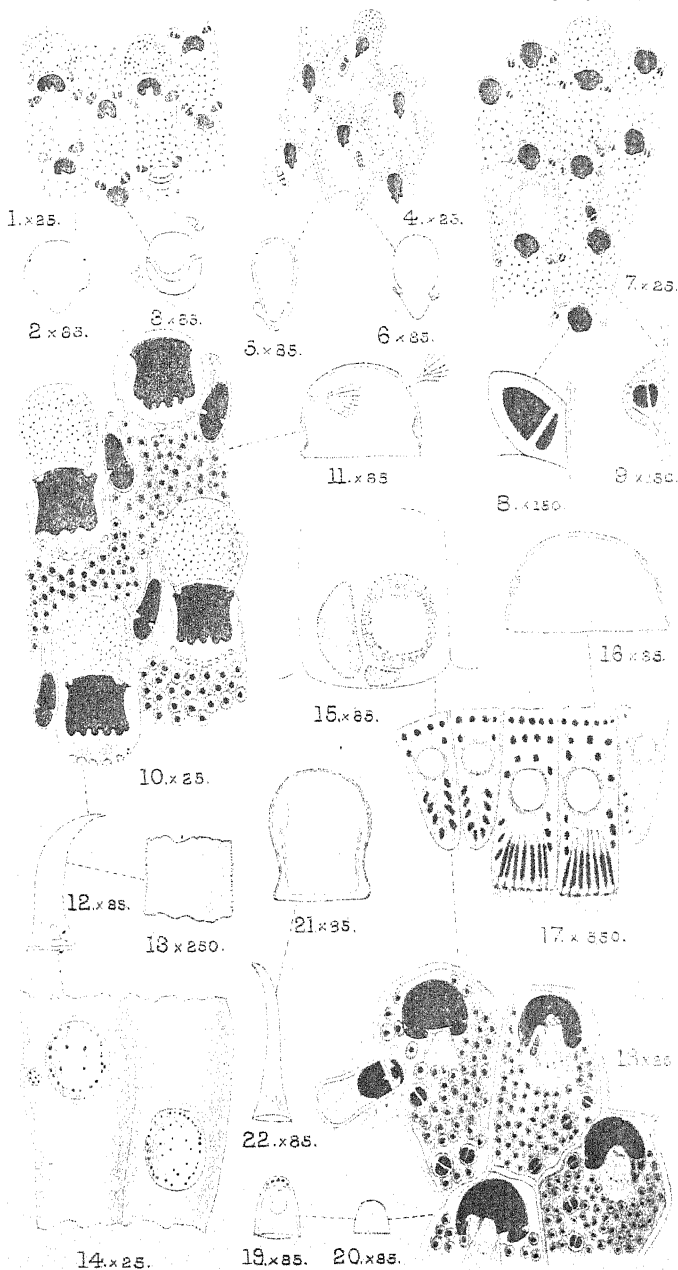


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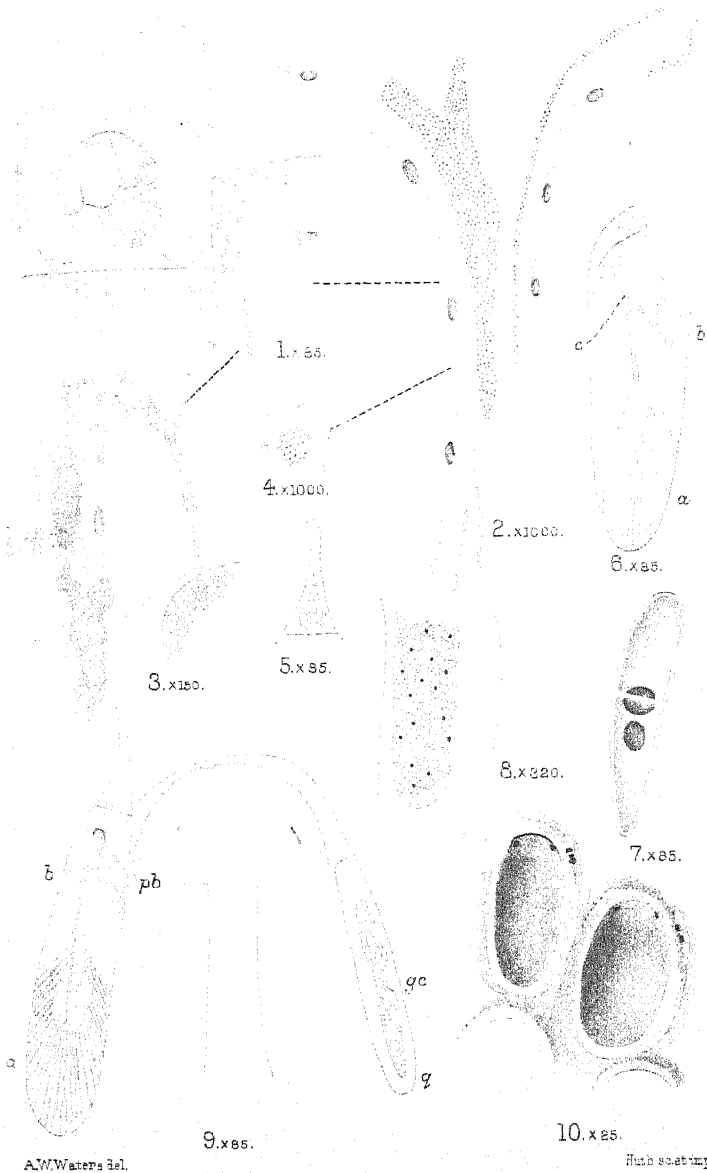
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BRYOZOA FROM ZANZIBAR.









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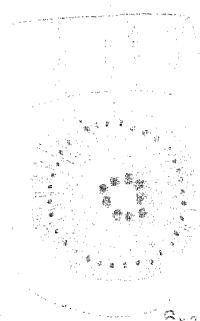
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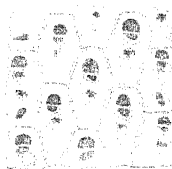
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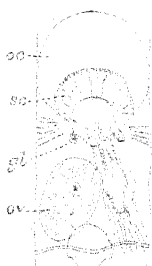
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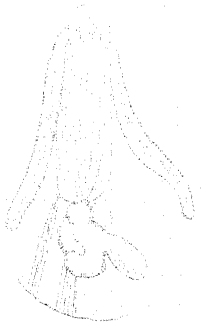
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15. x 50.



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Ruth. ac. on temp.

BRYOZOA FROM ZANZIBAR.



(2) The nature of the articulation can be used in grouping the *Scrupocellariidæ*, the other characters being the ovicells, vibracula (especially the number at a bifurcation), and the band, perhaps a spermotheca at the distal end.

(3) The difference in form and position of the ovaria in *Bugula* and *Scrupocellaria* gives a generic character, and the same is the case in other genera (p. 476). The form of the ovaria is likely to give us considerable assistance in classification, but as the ovaria pass through various stages of development, time and caution are requisite to make it fully available.

(4) In *Membranipora armata* Hasw. there are two mature polypides in most zoecia, and on one side of the zoecium there is a long chambered avicularium, whereas on the other side there is a similar long chamber containing a secreting gland (p. 488).

(5) In some species of *Schizoporella* a bar curving towards the sinus is seen across the operculum. This is the commencement of the lower wall of another zoecial layer, and in many cases the distal walls are seen to extend over the operculum (p. 504).

(6) In *Diplodidymia complicata* Rss. a small ovum starts in a small sac hanging down from the opercular region. Both grow large, and the larva ultimately fills up a large portion of the zoecium (p. 491).

Some of the species in this collection were also found in Crossland's Red Sea collections, and my report thereon is quoted with a shortened reference\*.

This communication may be considered as part of a series dealing with tropical forms, of which three papers on the Red Sea etc. have been published; and I have a small collection from Cape Verde, also collected by Crossland.

From the locality Wasin about 60 species were procured, and from Ras Osowamembe about 30 in all.

Since the examination of this Zanzibar collection was commenced, Levinsen has published his 'Morphological and Systematic Studies on the Cheilostomous Bryozoa,' and we have for some time been anxious to see his ideas on classification developed. He has given the particulars of much valuable detail examination of the calcareous parts of the Bryozoa, and doubtless many of the characters he deals with will receive increased attention, and our knowledge is much advanced by the wealth of observation.

Unquestionably much of his altered classification will be adopted; but if any of us thought that all our troubles would be ended as soon as Levinsen published his results, we find that this is far from being the case. We have to examine each new grouping, and see whether, when other characters are examined, they uphold suggested alterations; also, do other species of the groups fall into place? I already see where some modifications will be required, and no doubt other workers who have carefully

\* Journ. Linn. Soc., Zool. vol. xxxi. pp. 123-181, 231-256.

examined Levinsen's great work are coming to similar conclusions, and in this way our starting from Levinsen's standpoint, and using it as a stepping-stone, should ultimately advance the correctness of the classification very much. At present the position remains very difficult, since for a large part we are not sure what will be accepted.

I do not want to be misunderstood as giving an adverse criticism, and so would add that the task was too great to be final, as Levinsen must have fully felt; and we must now be alive to the fact that, in the future, classifications will to a large extent be based upon the structure of the soft parts, which furnish a very large number of characters, some of which are of great value, while others will not be found very useful. For every external character there are many internal ones of importance.

It must be emphasized that, as I have often said\*, characters of great value in one group or family are almost useless in the next; and all attempts at fixing certain characters as being of A1 importance, others of secondary importance, and so on down the scale lead to no result, but we must get together our groups of species based upon as many characters as possible, and gradually build from them larger divisions; and this process must be slow, but it will be natural, whereas the attempt to work from the larger divisions has led to false results.

As a case in point, Levinsen makes great use of the rosette-plates, which I have found in certain cases to give most useful results, in other families none at all; and in tabulating Levinsen's results we find that the family character is often uni- or multiporous, with or without pore-chambers, that is to say, the character in such cases is of no value for the higher group. In those families in which we should have been most glad of help, namely, in Membraniporidae, Cribrilinidae, Microporidae, Escharidae, Smittinidae, it is pore-chambers or uni- or multiporous rosette-plates, and in eight other families uni- or multiporous rosette-plates; also in genera we find the same range, so that, while Levinsen's work in this direction is very valuable, care is required lest we attach undue importance to the rosette-plates or any one character.

Where the opercular aperture is not on a level with the frontal surface of the zoecium there is often a shelf upon which the distal end of the operculum rests, and Levinsen has shown that this is a character of some value; but here, again, we must not expect too much. The value of most of the characters used by Levinsen, even for the main divisions, are still on trial.

Levinson has followed † Norman in using names given by the

\* Page 71. Levinsen expresses these facts as follows:—"The same structural feature in different systematic divisions can have a very different systematic importance, so that characters which are constant in one genus or family, in other corresponding divisions are not always constant even within the species."

† Since I wrote the above, Canu has sharply criticised Norman's suggested alterations of generic names (Rev. Crit. de Paléozoöl. vol. xvii. p. 49, 1913).



earlier authors in a sense different from that applied to them for generations; and not only that, but generic names now well established are shifted to be used instead of other well-established names. *Cellaria* is to be replaced by *Cellularia*, a name that has been used in numerous senses during the lifetime of most of us. There is no rule obliging us to revert to old names which were made for genera without any adequate and recognisable description; but even if a rule were being broken, we should continue to do so in order to stay the appalling confusion caused by this desire to keep alive a name in its doubtfully supposed original sense. *Cellaria* still means for me what it has meant all my scientific life. I do not accept *Lepralia* as meaning *Membraniporella*, and this Levinson also refuses to do and gives an amended description of *Membraniporella*; but I am not prepared to accept *Aspidelectra*, and should place *melontha* under *Membraniporella*. Nor is the variously used *Escharoides* a satisfactory name, seeing that it was only given for a subgenus of *Cellepora* based upon characters seen to be useless. *Discopora* is another genus that should have been dropped, as it was quite insufficiently described at first; in fact, the name was given by Lamarek to a Cheilostome and by Fleming to a Cyclostome, so that it has been employed for all kinds of unrelated things, as *Cellepora*, *Haloporella*, *Membranipora*, *Mucronella*, *Smittina*, *Palmicellaria*, *Diastopora*, *Lichenopora*, *Tubulipora*, etc., and has been variously used by palæontologists. It has not been proposed to retain *Discopora* on account of the definition, which now tells us nothing, but from what is supposed to be the first-mentioned species of an incongruous group.

Such changes back to discarded genera add much to the difficulties of those who are closely following all that is written; and are not these premature and puzzling changes of names keeping back new workers from entering the thinning ranks? Until we are sure of the characters, and have enough material to test the relationships, we must often gather information round species and genera the names of which we know will ultimately be changed or disappear.

I have again to thank Mr. Kirkpatrick for allowing me to make frequent comparison with the British Museum collections. The Plates were mostly drawn before the appearance of Levinson's work, otherwise they would have been slightly differently arranged. Miss Thornely's paper, "The Marine Polyzoa of the Indian Ocean from H.M.S. Sealark," Trans. Linn. Soc. vol. xv. pp. 137-157, has also appeared during the preparation of my paper. It materially increases our knowledge of the distribution of tropical Bryozoa from moderate depths.

Other groups collected by Mr. Crossland from Zanzibar have already been described by specialists in the Proceedings of this Society.

Table of Distribution from West to East.

	Page.	Atlantic. British.	Mediterranean.	Red Sea.	Indian Ocean. N. = North, S. = South.	Ceylon. South Africa.	Australasia.	Japan.	Fossil.	
<i>Actea anguina</i> L. ....	463	+	+	+	...	+	+	+	+	N. Pacific.
" <i>truncata</i> Landsb. ....	465	+	+	+	...	...	...	...	+	
<i>Brettia tropica</i> , sp. n. ....	465									
<i>Synactum aciculare</i> Pieper ....	465	+	+	+	+ N., S.	+	+			
" <i>penbaensis</i> , sp. n. ....	465									
" <i>contorta</i> , sp. n. ....	466									
<i>Eucratea chelata</i> L. ....	466	+	+	+	...	+	+	...		California.
<i>Beania spinigera</i> MacG. ....	467				...	...	+			{ Pacific, Burmah.
" <i>mirabilis</i> Johnst. ....	467	+	+	+	...	+	+			
<i>Bicellaria chuakensis</i> , sp. n. ....	467									
<i>Stirparia exilis</i> MacG. ....	468				...	...	+			
" <i>zanzibariensis</i> , sp. n. ....	469									
" <i>dendrograpta</i> , sp. n. ....	470						+			
<i>Bugula neritina</i> var. <i>minima</i> Waters	471			+	+ N., S.	...	+			
" <i>robusta</i> MacG. ....	471				...	+	+			
<i>Scrupocellaria ferox</i> Busk ....	476						+			
" <i>cercicornis</i> Busk ....	477			+		+	+			
" <i>macandrei</i> Busk ....	477	+	+	Hell.	+ S.	...	+			Loyalty Isl.
" <i>pilosa</i> Aud. ....	478									
" <i>wasinensis</i> , sp. n. ....	479									
<i>Canda retiformis</i> , Pourtales ....	479	+	...	...	+ S.	+	...	...		Loyalty Isl.
<i>Catenaria lafontii</i> Aud. ....	481	+	+	+	+ N., S.					
" <i>diaphana</i> Busk ....	482	+								
<i>Vittaticella elegans</i> Busk ....	484				+ N.	+	+	+		
" " var. <i>zanzibari-</i> <i>ensis</i> , nov. ....	485									
<i>Membranipora savartii</i> Aud. ....	486	+	...	+	+ N., S.	+	+	+	+	
" <i>armata</i> Hasw. ....	486				...	...	+	+		
" <i>catenularia</i> Jameson ....	488	+	+	...	...	...	+	+	+	
<i>Farcimia oculata</i> Busk ....	489	+	...	+	+ N., S.	+	+	+	+	
<i>Diplodidymia complicata</i> Rss. ....	490				...	...				New Guinea.
<i>Chlidonia cordieri</i> Aud. ....	492	+	+	+	...	...	+			
<i>Cellaria gracilis</i> var. <i>tessellata</i> nov.	495									
" <i>wasinensis</i> , sp. n. ....	495									
<i>Thairopora nanillaris</i> Lamx. ....	497				...	...	+			
<i>Steganoporella magnilabris</i> Busk ....	498	+	...	...	+ N., S.	+	+	+	+	Brazil.
<i>Cribrilina radiata</i> Moll. ....	501	+	+	+	+	+	+	+	+	
<i>Hippothoa distans</i> MacG. ....	501	+	+	...	...	...	+			
" <i>divaricata</i> Lamx. ....	501	+	+	...	...	+	+			
<i>Schizoporella micornis</i> Johnst. ....	501	+	+	+	...	...	+	+	+	
" <i>pertusa</i> Esper ....	502	+	+	+	+ N.	...	+	+	+	Pacific.
" <i>nivea</i> Busk ....	502			+	+ N., S.	+	+			
" <i>montferandi</i> Aud. ....	506			+	+ N.	...	+	+		
<i>Gemellipora protusa</i> Thornely ....	506			...	+ N.	+				
<i>Trypostega venusta</i> Norm. ....	506	+	...	...	+ N.	...	+	+	+	{ Lifu, Mauritius.
<i>Arthropoma cecilii</i> Aud. ....	508	+	+	+	+ N., S.	+	+	+	+	
<i>Osthimosia zanzibariensis</i> , sp. n. ....	508									
<i>Lagenipora rota</i> MacG. ....	510				...	...	+			
<i>Hasicellia australiensis</i> Hasw. ....	511				...	...	+			
<i>Tubucellaria cereoides</i> var. <i>chua-</i> <i>kensis</i> Waters ....	512				...	...	+	+		
" <i>fusiformis</i> d'Orb. ....	512				+ N., S.					
" <i>zanzibariensis</i> Waters ....	512									

\* This was not mentioned in my Red Sea paper, but I have a piece from a sounding-line.

Table of Distribution from West to East (continued).

	Page.	Atlantic.	British.	Mediterranean.	Red Sea.	Indian Ocean. N. = North. S. = South.	Ceylon.	South Africa.	Australasia.	Japan.	Fossil.	
<i>Smittina trispinosa</i> var. <i>protecta</i> Th.	513	+	...	...	+	+ N.	+					
" " var. <i>spathulata</i> MacG.	513	...	...	...	+	+ N.	+	...	+			
" <i>tropica</i> Waters	514	...	...	...	+							
" sp.	514	...	...	...								
<i>Lepralia feegensis</i> Busk	514	...	...	...	...	+ N.	+	?	...			Loyalty Isl.
" <i>turrita</i> Smitt.	516	+	...	...	...	+ N., S.						
" <i>wasineusis</i> , sp. n.	516	...	...	...	...							
" <i>cleidostoma</i> var. <i>inermis</i> Ort.	517	...	...	...	...					+		N. Pacific.
<i>Petralia japonica</i> Busk	518	...	...	...	+	+ N.	+	+	...	+		
" <i>chuakensis</i> , sp. n.	518	...	...	...								
" <i>vultur</i> var. <i>armata</i> , nov.	518	...	...	...								
? <i>Escharoides oclusa</i> Busk	519	...	...	...	+	...	...	+				
<i>Holoporella columnaris</i> Busk	521	...	...	...	...	+ N.	+	+	+	+		
" <i>aperta</i> Hincks	522	...	...	...	+	+ N.	+	...	...	+		Cuba.
" <i>albirostris</i> Sm.	522	+	...	...	...	+ S.	...	+	+	+		
<i>Microperella ciliata</i> Pallas	523	+	+	+	+	+ N.	+	+	+	+		
<i>Rhynchozoon profundum</i> var. <i>laminatum</i> , nov.	523	...	...	...								
<i>Retepora hirsuta</i> Busk	523	...	...	...	+	...	...	+				
" <i>producta</i> Busk	525	...	...	...	...	+ N.	...	+	+	+		
" <i>denticulata</i> Busk	526	...	...	...	...	...	...	+	+	+		
" <i>germanensis</i> Waters	526	...	...	...	+							
" <i>tubulata</i> Busk	526	...	...	...	...	+ N.	+	+	+			
? <i>Bifaxaria vagans</i> Thornely	527	...	...	...	...	+ S.						
<i>Adeonella platalea</i> Busk	529	...	...	...	...	+ N.	...	+	...			( China Sea.
<i>Adeonellopsis crosslandi</i> , sp. n.	531	...	...	...	...							( South Pacific.

Hincks records *Lepralia striatula* from Zanzibar.

*AETEA ANGUINA* Linnæus. (Pl. LXIV. figs. 1 & 2.)

For synonyms see Miss Jelly's Catalogue, and add:—

*Aetea anguina* Calvet, "Bry. Mar. de Cette," Trav. de l'Inst. de Zool. de l'Univ. de Montpellier, ser. 2, mem. 11, p. 8 (1902); Jullien & Calvet, Bry. prov. des Camp. de l'Hirondelle, p. 122 (1903); Thornely, "Ceylon Pearl-Oyster Fisheries," vol. iv. Suppl. Rep. xxvi. Polyzoa, p. 108 (1905); Robertson, "Non-Incr. Bry.," Univ. Calif. Pub., Zool. vol. ii. No. 5, p. 244, pl. iv. figs. 1-4 (1905); Norman, "Polyzoa of Madeira," Journ. Linn. Soc., Zool. vol. xxx. p. 283 (1909); Levinsen, Morph. & Syst. Studies on Cheil. Bry. p. 93 (1909); Canu, "Bry. Helv. de l'Egypte," Mém. de l'Inst. Egyptien, vol. vi. p. 190 (1912); Osburn, R. C., "The Bry. of the Wood's Hole Region," Bull. Fisheries Bureau, vol. xxx. p. 220, pl. xxi. figs. 14, 14 a (1912).

In the specimens from Wasin I have seen ovicells in the same position as those of *A. recta*, namely, at the top of the tubular projection at the back. This dorsal ovicell has now been seen

in *A. recta* from Rapallo\* and Naples in the Mediterranean, and in the 'Belgica' Antarctic material. Miss Robertson describes ovicells on the front, some distance down, but was in doubt as to whether the species was a true *A. anguina*. Whether she really had another species before her or not must be left uncertain, but certainly the front position as drawn by her is a very strange and unexpected one.

Miss Robertson has confirmed what I wrote about the ovaria occurring in the creeping part, and this seems to be the usual place; however, in the present specimens I do not find that the polypide extends far into this part, as it sometimes does in *A. recta* and as Miss Robertson describes and figures in *A. anguina*.

Smitt, Waters, Jullien, and Robertson have all shown that the polypide etc. does not entirely live in the tubular prolongation; but Jullien, although appreciating the fact, called this part the peristome or peristomia. Surely the peristome is something beyond the operculum and is the part where the polypide is only to be seen when extended; so that this term applied to *Aetea* is most unfortunate and misleading. This tubular prolongation has been called the neck, and the terminal portion the spoon, but no satisfactory name has been given to the creeping portion, which is only a part of the zoecium. There are 12 tentacles.

The diaphragm does not make an infold when retracted, like most of the Cheilostomata; and the appearance of setæ, which has frequently been alluded to, must be caused by a partial extrusion of the diaphragm. In some respects *Aetea* approaches the Ctenostome *Cylindroecium*, but no Ctenostome has an external ovicell.

I do not altogether understand what Levinsen† says regarding the ovicells of this species; for though the wall of the ovicell is so thin that the embryo can readily be seen, yet decalcified preparations and sections have been studied. If Levinsen means to suggest that the sacs containing the ova and embryos are only accidentally at the termination and might adhere in any position, then this is not the case, as I have now seen a large number, perhaps hundreds, always in exactly the same position, and see no reason why we should not speak of them as ovicells. One section shows the zoecial wall bulging out and the ovum partly in this portion, which is the commencement of the ovicell‡.

*Loc.* Arctic; Atlantic; Mediterranean; Gulf of Manar; Zanzibar (*Hincks*); S. Africa; Australia; New Zealand, Tasmania; Pacific? (*Robertson*); Tristan da Cunha ('*Challenger*'). Wasin, Brit. E. Africa, 10 fath. (500 fath.), collected by Crossland.

*Fossil.* Upper Tert. Italy (*Veriani*), Helvetian of Egypt (*Canu*).

\* "Bryozoa from Rapallo," Journ. Linn. Soc., Zool. vol. xxvi. p. 5, pl. i. figs. 1-5 (1896).

† Morph. & Syst. Studies on the Cheil. Bry. p. 93 (1909).

‡ Since the above was written, Prof. R. C. Osburn has confirmed the existence of ovicells in the position described, having found numerous such ovicells in specimens from Fish Hawk Station: see "Bryozoa of the Wood's Hole Region," Bull. of the Bureau of Fisheries, vol. xxx. Document No. 760, p. 220 (1912).

§ These and similar numbers are Crossland's registration numbers.

*AETEA TRUNCATA* Landsborough. (Pl. LXIV. fig. 3.)

There are only small fragments from Prison Island, Zanzibar Channel. The creeping tube or stolon is dotted in just the same way as the erect tube.

*Loc.* Arctic; British; Danish; Madeira, Naples, Rapallo, Cette. Prison Island, Zanzibar Channel (505), 8 fath., collected by Crossland.

*Fossil.* Helvetian, Egypt (*Canu*).

*BRETTIA TROPICA*, sp. n. (Pl. LXIV. figs. 4, 5.)

There are only the zoecia figured, and it will be seen that the species is closely allied to *B. australis* Busk, but differs in the shape of the area, which in *B. tropica* is about the length of a zoecium. There are on the dorsal surface the two light disks\* on each side as in *B. longa* Waters, but in *B. tropica* the distal ones are very minute with the proximal one much larger. The lower zoecium arises from a calcareous knob, from which stolons spread out. The zoecium is calcareous, and most of the species of *Brettia* are more or less calcareous, but with such small fragments we cannot know much about its relationships.

I found species of *Brettia* in the Arctic and one in the Antarctic, and though the differences are very small it does not seem that the present form can be placed with any of those already described. *Brettia* may have avicularia, but then it has been called *Corynosporella* Hincks.

*Loc.* Wasin, Brit. East Africa, 10 fath. (501), collected by Crossland.

*SYNNOTUM AVICULARE* Pieper.

Waters, Rep. Sudanese Red Sea, p. 129.

*Loc.* (additional). Wasin, Brit. E. Africa, 10 fath. (501); Ras Osowamembe, 10 fath. (504); Meweni Bay, 6 fath. (510).

*SYNNOTUM PEMBAENSIS*, sp. n. (Pl. LXIV. figs. 12-15.)

Zoarium with a spreading ramifying stolon, from which several erect stems arise, just as in *Stirparia* etc. The stem is about the same size as the creeping stolon, and is smooth for about the length of two or three zoecia, then there is a short zoecium followed by the pairs of zoecia.

The zoecia are shorter and stouter than those of *Synnotum aviculare* P. At one side at the distal end there is a round pedunculate avicularium, but no sessile avicularium as in *S. aviculare*. The first zoecium of each branch is uniserial, as is also the case in *S. aviculare*, *Notamia bursaria* L., *Dimetopia*, and *Calwellia*, whereas in *Gemellaria loricata* L. there is a pair of zoecia at each fresh bifurcation. The pairs of zoecia turn alternately slightly to right and left, and there are radicles from between the zoecia just as in *Synnotum aviculare*. There seem

\* There are similar disks in *Catenaria* and *Vittaticella*.

to be several pores in the large distal rosette-plate. There are 10 tentacles.

*Loc.* Wasin, Brit. E. Africa, 10 fath. (501); Chuaka, Zanzibar, 2 fath. (508); Chaki-Chaki Bay, Pemba Island, near Zanzibar (517), collected by Crossland.

*SYNNOTUM CONTORTA*, sp. n. (Pl. LXIV. figs. 16-18.)

*Synnotum aviculare* Robertson, "Non-Incrusting Bryozoa," Univ. of Calif. Publ., Zool. vol. ii. p. 286, pl. xiv. figs. 84, 85 (1905).

The zoarium is coiled up, especially at the end. The branches of the zoarium dichotomise, and consist of pairs of zoecia back to back directed alternately in the opposite directions at right angles.

The zoecia are wide, subtruncate at the top, diminishing regularly to the base, with a sessile avicularium at one or both sides near the distal end, and there are a few large rounded, pedunculated avicularia replacing one of the sessile avicularia, but none of these are found in the older zoecia; the area is large, occupying more than two-thirds of the front, and the calcareous layer is much more solid than in any other of the Gemellaridæ examined. The first zoecia at the bifurcations are single, whereas the next ones are double, being back to back. There are long radicles from the side of the zoecia. In the lateral wall there are two rosette-plates near the distal end.

There are 11 tentacles.

We know *Gemellaria loricata* L. without any avicularia, *S. pembaensis* nov. with terminal pedunculated avicularia, the present species with sessile avicularia and a few short thick pedunculated avicularia, and *S. aviculare* also with both sessile and pedunculated avicularia. The presence or absence of avicularia is constantly turning out an unsatisfactory generic character, and I have never felt quite satisfied that a new genus was required for *Synnotum*.

Miss Robertson's figure shows the zoecia more attenuated below, but it certainly seems that this is the species she described.

*Loc.* Chuaka, Zanzibar, 2 fath. (508); Chaki-Chaki, Pemba Bay, near Zanzibar, low water (517); Wasin, Brit. East Africa, 10 fath. (501).

*EUCRATEA CHELATA* Linn.

See Miss Jelly's Catalogue, and add:—

*Scruparia chelata* Kirchenpauer, Bericht über die tersuchungs-Fahrt der Pommerania, "Bryozoa," p. 181 (1871).

*Eucratea chelata* Levinsen, Zool. Danica, p. 42, pl. i. figs. -9; Calvet, Bry. de Cette, p. 12; Robertson, "Non-Incrusting Bryozoa," Univ. of Calif. Publ., Zool. vol. ii. p. 248, pl. v. figs. 7-9 (1905); Barrois, Emb. des Bry. p. 194, pl. xv. figs. 10-12 (1877);

Osburn, "Bry. of Wood's Hole Region" Bull. Bur. Fish. vol. xxx. p. 221, pl. xxi. fig. 15 (1912); Nordgaard, "Die Bry. des West. Norwegens," Die Meeresfauna von Bergen, p. 76.

A few zoecia were seen from Wasin.

*Loc.* As far north as the Lofoten Islands; Atlantic; British; Mediterranean; California; Australia; S. Africa (*A. W. W. coll.*). Wasin, Brit. East Africa, 10 fath. (501), collected by Crossland.

#### BEANIA SPINIGERA MacGillivray.

*Diachoris spinigera* MacG. Trans. Roy. Soc. Vict. vol. iii. p. 165, pl. ii. fig. 12 (1859); Prod. Zool. Vict. dec. v. p. 32, pl. xvi. fig. 3; Waters, Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 94 (1887).

There are some small specimens from Wasin which correspond in most particulars, though the avicularia are materially smaller than the type, more like those of *B. intermedia* Hincks. There are three terminal spines and usually 5-6 delicate lateral spines.

*Loc.* Victoria (Australia); New South Wales. Wasin, Brit. East Africa, 10 fath. (501), collected by Crossland.

#### BEANIA MIRABILIS Johnston.

For synonyms see Miss Jelly's Catalogue, and add:—

*Beania mirabilis* Hincks, Ann. Mag. Nat. Hist. ser. 3, vol. viii. p. 36 (1862); op. cit. ser. 5, vol. xiii. p. 357 (1884); op. cit., ser. 5, vol. xix. p. 215 (1887); Waters, Journ. Linn. Soc. Zool. vol. xxvi. p. 17, pl. ii. fig. 1 (1896); Jullien & Calvet, 'Bry. prov. des Camp. de l'Hirondelle,' p. 38 (1903); Thornely, Ceylon Pearl-Oyster Fisheries, vol. iv. Suppl. Rep. xxvi. p. 109 (1905); Robertson, "Non-Incrust. Chil. Bry." Univ. of Calif. Publ., Zool. vol. ii. p. 276, pl. xii. figs. 63, 64, & fig. in text (1905).

*Loc.* Northern; British; French coasts; Atlantic (*Jull. & Calv.*); Mediterranean; Ceylon (*Th.*); Burmah (*H.*); Australia; Pacific coast of N. America (*Rob.*). Meweni Bay, Zanzibar (510), collected by Crossland.

*Beania* has been considered to belong to the Flustridae by Busk, and to Bicellaridae by Levinsen, but the large embryo found by me in *B. magellanica*\* seems to indicate the probability of the genus standing elsewhere. There are 20-26 tentacles in *Beania*, whereas in Bicellaridae and its allies there are usually fewer, 12-18. *B. magellanica* B. has 23-26; *B. hirtissima* Hell., 20-30; *B. hyadesi* Jull., 20; *B. quadricornuta* H., 23 (*W.*); *B. spinigera* MacG., 20; *B. mirabilis* Johnst., 20.

#### BICELLARIA CHUAKENSIS, sp. n. (Pl. LXVIII. figs. 7, 8.)

The zoarium arises from a long, erect primary with radicles; it frequently anastomoses, forming a colony about 7-8 mm. high.

The primary zoecium has an elongate area with nine short

\* Ann. & Mag. Nat. Hist. ser. 8, vol. ix. p. 493 (1912).

spines, the next zoecium has seven spines, while the younger zoecia have usually three spines, two outer ones and one inner, though there may be occasionally two or four spines instead of three. The area is less than half the length of a zoecium, and the pedunculate avicularia are placed at about half the height of the area, whereas in *B. ciliata* they are much below it. The avicularia are of moderate size and similar in shape to those of *B. ciliata*; however, avicularia do not occur on any of the lower zoecia, so that, counting from the primary, no avicularia will be found before about the 18th zoecium.

The pedunculate ovicell, directed laterally as in *B. ciliata*, is situated on the inner side near the distal end.

*Loc.* Taken in tow-net, Chuaka Bay, Zanzibar (515); Wasin, Brit. E. Africa, 10 fath. (500), on *Steganoporella magnilabris*; Chuaka, 2-3 fath. (512), collected by Crossland.

*STIRPARIA EXILIS* MacGillivray. (Pl. LXVI. figs. 1-3.)

*Stirparia exilis* MacG. "Desc. of New or Little-known Polyzoa," pt. xiii. Proc. Roy. Soc. Vict. n.s. vol. ii. p. 107, pl. iv. figs. 1-1 b (1890).

In the Wasin specimens the lower part of the stem is buried in sponge and cannot be completely examined; the upper part is annulated for a short space; the rest is smooth, unjointed, and without any strengthening rods, but at irregular intervals there are contractions, or sometimes two or three together, with rosette-plates across the stem in places. Although these stems differ from those of the other two species found, yet they are divided up by these contractions into lengths often about equal to those of *S. dendrograpta*; however, the growth is much simpler, so that, perhaps, *S. exilis* may ultimately have to be placed in another genus. Fresh branches are given off at right angles to the main stem and start from an expanded disk (fig. 3).

The tuft is 5-6 mm. long, and the zoecia face to the outside of the tuft. There are about 12 tentacles. The area is about two-thirds of the length of a zoecium; there are three spines, or, in parts two; and only a very few, almost globular, avicularia have been seen (about two in each tuft), and these are short with apparently a wide mandible rounded at the end. The avicularia are attached just below the area and there are no ovicells, only the commencement of one. MacGillivray found neither avicularia nor ovicells.

The opercular opening is low down. At a bifurcation one zoecium extends up a short distance on the opposite side of the bifurcation (fig. 1), and this is well shown in the British Museum specimens of *S. exilis* MacG., from Port Phillip Heads.

The mounted specimen from the 'Challenger,' named *S. glabra*, is *S. annulata* Mapl., though there are mounts of a stem of a species which are like those of *S. glabra* and *S. dendrograpta*. Busk's figure, however, seems to show *S. glabra* H., so that we have a puzzle; but we may be right in concluding that *S. glabra*



and *S. annulata* were both obtained from the 'Challenger' Station, off Bahia. In the British Museum 'Challenger' specimen there are six spines to the primary of the tuft, not a number as figured; there are no avicularia or ovicells, but there is a central spine in the same position as the avicularium in *S. glabra* H.

*Loc.* Port Phillip Heads (*MacG.*). Wasin, Brit. East Africa, 20 fath. (522), collected by Crossland.

STIRPARIA ZANZIBARIENSIS, sp. n. (Pl. LXVIII. figs. 1, 2; Pl. LXIX. fig. 14.)

The stem throws out branches which may bear a tuft 6-7 mm. long, and the internodes of the stem are approximately equal.

The zoecia are alternate and turn partly away from each other, that is, the central line of the branch is raised so that the zoecia slope laterally downwards. The zoecium is much wider at the distal end than below, and the area is rather more than half the length of a zoecium. The first zoecium of a tuft has 9-11 long spines, usually six on one side and four on the other (or dorsal side) with the central spine long; then the second, third, and sometimes fourth zoecium have several spines, whereas the normal zoecia have usually only one stout spine at the upper inner angle, though occasionally there is also one at the outer angle.

There is sometimes an avicularium to the second zoecium, and this and the subsequent avicularia, which are long and narrow, are situated close to the base of the zoecium.

There are about 14-15 tentacles.

On the lower part of the stem or stolon the radicles are sometimes replaced by capsules, similar to those described in my paper, "Bryozoa from Rapallo,"\* and they may be filled with bright yellow homogeneous contents. Levisen† refers to similar capsules as occurring in *Bugula caliculata* Lev.

The ovicells are pedunculate, and there is a calcareous cover over a part only, not exceeding the half of a globe, so that the embryo is thereby but slightly protected, sometimes not at all. The calcareous wall of the ovicell is made of plates deposited from centres and looking like the shell of a turtle.

The ovaria are central immediately proximal to the cæcum, and the testes fill up the proximal part of the zoecium. No ovarium in my sections has more than one ovarian cell.

The zoarial growth is similar to that of *S. dendrograpta*, sp. n., with the long nodes as depicted in Pl. LXVI. fig. 4; but the tufts are longer, and both the stout spinous processes and the long avicularia are distinguishing characters. There is no line of chitinous thickening as in *S. dendrograpta*.

*Loc.* West Australia, some imperfect specimens in my collection. Chuaka, Zanzibar, 3 fath. (506), collected by Crossland.

\* Journ. Linn. Soc., Zool. vol. xxvi. p. 19, woodcut fig. 6 (1896).

† Morph. & Syst. Studies on Cheil. Bry. p. 102.

*STIRPARIA DENDROGRAPTA*, sp. n. (Pl. LXVI. figs. 4-9.)

The stems grow from spreading stolons, and at frequent intervals branches occur which may bear tufts of zoëcia or may produce other branches, and both the original stem and the branches are divided into segments approximately equal, though an internode below a tuft is frequently shorter than the others. From the base of most of the internodes there is a radicle or a pair with frequently a cervicorn grapnel at the end. The colony may grow to at least 50 mm. long, and the tufts 3-5 mm. long originate from a zoëcium entirely different from the later zoëcia, having more or less the character of a primary zoëcium. When first described the stem of *Stirparia* was considered to be the equivalent of radicles, but this is not the case.

The first zoëcium (figs. 4, 6) has the area a little more than half the length of the zoëcium and is surrounded by eight very long spines, often attaining about four times the length of a zoëcium. The spines of the first zoëcium of a tuft are, however, not bilateral, but are five on one side and three on the other, the smaller number being on the side from which the next zoëcium grows. The next zoëcium has a somewhat similar area, with about five spines, and the avicularium is near the base of the area, while the following zoëcium approximates to the later zoëcia in having the avicularium somewhat higher than in zoëcium no. 2, though still low down. In subsequent zoëcia they are placed still higher, their normal position in the older zoëcia being at the distal end on the outside corner. Typically they may be terminal in the fourth pair of zoëcia, or they may continue lateral until the eighth, and after the appearance of a terminal one subsequent zoëcia are also generally at the corner of the distal end.

The avicularia are short with a distinct beak.

The branches of the tufts do not form a complete cup as in *S. exilis* MacG. and *S. zanzibariensis*, sp. n., and the zoëcia are on the inside of the cup, whereas in the others they are on the outside. The branches of the tuft dichotomise, and the spread-out fan-shaped tuft is 3-5 mm. long, having often ten pairs in succession.

The zoëcia are alternate and diagonal with the area a little more than half the length of a zoëcium, and the full number of spines is three long ones at the distal edge, though many of the lower zoëcia may have one and the younger zoëcia two spines; nor do the same number occur on both sides of a branch, the zoëcia on the outer zoarial side having more spines than those on the inner; with three on the outer, there is often only one on the inner side.

The ring-shaped oblique chitinous thickening, to which Levinsen\* refers as occurring in *Bicellaria ciliata* L., is often

\* Morph. & Syst. Studies on Cheil. Bry. p. 101. Levinsen puts *B. caliculata* Lev. under *Bugula*, but his Pl. iii. fig. 1 shows the character of *Bicellaria* in having the long tubular proximal part.

quite distinct on the dorsal surface without being seen on the anterior surface; in other cases a mark is seen all round (fig. 4). When put into Eau de Javelle the zoecium often breaks off at this line, and it is seen that this proximal tubular part is connected at the base with the lower zoecium through a rosette-plate. A rosette-plate higher up connects with the next younger zoecium (fig. 7).

The ovicell is lateral and pedunculate, and there are about 12 tentacles.

Radicles may occur in abundance on the lower zoecia and not merely from the normal position at the proximal end of the node.

Immediately below the cæcum there is a small globular body which, as it grows, is seen to be the ovarium, but in no case has more than one ovarian cell been seen. The same thing occurs in various Cellulariæ.

In many respects *S. dendrograpta* resembles *S. glabra* Hincks, but that species has the stem internodes long and short alternately and also there is no avicularium at the distal end in *S. glabra*. From *S. exilis* MacG., it differs in the internodes being approximately equal and in the different character of the avicularia. *S. exilis* has 6-7 spines on the primary zoecium.

The graptolite, *Dendrograptus serpens* Hopkinson\*, has similar colonies growing on a stout stalk, and the subcolonies and branches are about the same size as those of the *Stirparia*; and some subcolonies I collected in Llandrindod Wells of *D. serpens* H., or a closely allied species, have the branching quite similar to this *Stirparia* and might have been an impress of it, but as competent authorities have found it to be a graptolite, it shows how identical the growth may be in widely different classes. The name is given on account of the superficial likeness.

*Loc.* Chuaka, Zanzibar, 2 fath. (508), collected by Crossland.

There is a specimen of *S. dendrograpta* from Port Phillip in the British Museum.

#### BUGULA NERITINA var. MINIMA Waters.

Waters, "Rep. Sudanese Red Sea," p. 136, pl. xi. figs. 4-7, for syn., and add Thornely, "Mar. Polyzoa of the Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 141.

*Loc.* N. S. Wales (*W.*); Red Sea (*W.*); Cargados Reef, Providence, 50-78 fath. (*Th.*). Prison Island, Zanzibar Channel, 8 fath. (505); Ras Osowamembe, Zanzibar Channel, 10-20 fath. (514); Chuaka, Zanzibar, tow-net (515), collected by Crossland.

#### BUGULA ROBUSTA MacGillivray. (Pl. LXIX. figs. 15, 16.)

*Bugula robusta* MacG. Trans. R. Soc. Vict. vol. ix. p. 129 (1868); Prod. Zool. Vict. dec. viii. p. 29, pl. lxxviii. fig. 1 (1883).

*Bugula capensis* Busk, MSS.

\* Hopkinson & C. Lapworth, "On the Graptolites of the Arenig and Llandeilo Rocks of St. Davids," Quart. Journ. Geol. Soc. vol. xxxi. p. 665, pl. xxxvii. fig. 3 (1875).

There is a specimen from Wasin which has the zoecia a trifle smaller than the South African and Australian specimens, and the avicularia are somewhat smaller; however, in a specimen in my collection, determined by Busk as *B. capensis*\*, there is one small avicularium, while the rest are large. There is no real spinous process at the outer angle, but neither do I find more than a projection in any of my specimens from other localities.

The distal rosette-plates are all close to the basal wall and very small, so that it is difficult to distinguish them. In some other *Bugula* they are similarly situated, though in others they are spread over the wall. There are no ovicells in this specimen, but the species has lateral ovicells like those of *B. neritina* L., and the brown colour suggests its belonging to the *neritina* group.

The primary zoecium is very long and narrow, followed by a second long one, then a zoecium about the ordinary length, after which the growth is biserial. The first two zoecia remind us of the segments of the stem of various *Stirpariae*.

*Bugula*, as a rule, shows no articulation, but *B. reticulata* B. is distinctly articulated—that is, at the bifurcation there are distinct thick articular chitinous tubes.

Other tropical species of *Bugula* are:—*B. dentata* Lamx., *B. mirabilis* B., *B. versicolor* B., *B. reticulata* var. *unicornis* B., *B. gracilis* B., *B. neritina* var. *rubra* Thornely, *B. neritina* var. *tenuata* Th., *B. neritina* var. *ramosa* Th. These last two in many particulars resemble *B. reticulata* Busk. Most of the tropical species have a very wide distribution.

Loc. Victoria (McG.); South Africa (as *capensis*); Port Elizabeth, S. Africa (*A. W. coll.*). Wasin, Brit. E. Africa (501), collected by Crossland.

#### SCRUPOCELLARIDÆ.

Levinson† does not consider that *Menipea* can be divided up, as I‡ proposed, by the character of the jointing, and on p. 133 gives his account of the articulation of “all Bryozoa that occur in jointed colonies,” but his account is not exhaustive. Dealing now with much more material than on the previous occasion, my suggestion is more fully tested.

The jointing in the Scrupocellaridæ varies considerably, giving useful specific characters, and it is most important that we should trace it from its simplest to its most complicated condition. As I have shown, in most articulated Bryozoa the branches are at first continuous, and the last two or three bifurcations may show no sign of rupture, which only takes place after the chitinous tubes have been formed; and in most articulated Bryozoa the chitinous tube is formed within the calcareous wall, though in some it may be formed merely within the membranous

\* See my remarks, Journ. Linn. Soc., Zool. vol. xxxi. p. 137 (1909).

† Morph. & Syst. Studies on the Cheil. Bryozoa, p. 133 (1909).

‡ Journ. Linn. Soc., Zool. vol. xxvi. p. 2 (1896).

wall. Usually, in *Scrupocellariidæ*, the inner zoecium of the new pair is jointed close to the proximal end (Pl. LXVIII. fig. 14), but the position of the articulation of the outer zoecium varies considerably, having the part below the articulation much larger than the similar portion in the inner zoecium. There are three exceptions to this rule—*Menipea cirrata* Ell. & Sol., *M. smittii*\* Norm., *M. flagellifera* Busk—all three of which are without a scutum †.

A.—Beginning with what seems to me the simplest form of articulation, namely, that found in *Canda retiformis* Pourt. (Pl. LXIX. fig. 6), though both genus and species have previously been described as non-articulated in consequence of the chitinous tube being often entirely covered by the calcareous wall, in which as yet there is no rupture, so that decalcification is necessary in order to study the articulation. As mentioned on p. 480, in the younger branches no articulation is found, but in the older ones there is a chitinous tube on the inside of one of the two branches and a similar tube on the opposite side in the next branch, and so on alternately (fig. 6).

B.—From the simple form of *Canda*, we pass on to that of *Scrupocellaria* with two chitinous tubes, but with the outer zoecium having the articular tube near the middle of the zoecium (Pl. LXIX. fig. 8). As an example, *S. jolloisii* Aud.

C.—In the following group the chitinous tube in the outer zoecium is very much lower than in B, but is not, however, close to the proximal end of the zoecium. The articular tubes are here narrower, more distinct, and often separated as in *Menipea patagonica* Busk (Pl. LXIX. fig. 11). As examples, *M. ternata* Ell. & Sol., *Bugulopsis peachii* Busk (Pl. LXIX. fig. 10), *M. occidentalis* Trask, *M. porteri* MacG.

D.—We pass next to a group in which both articular chitinous tubes are close to the proximal end of the zoecia. I spoke of the proximal ends of these new zoecia as small chambers, but now consider that it would be better to compare them with the "basis rami" (*Harmer*) of *Crisia*, and think the designation may be used here, remembering that they are really the beginnings of new zoecia. As examples, *Menipea buskii* W. Th. (Pl. LXIX. fig. 12), *M. crystallina* Gray, *M. cervicornis* MacG., *M. occidentalis* Trask, *M. cirrata* Ell. & Sol.

\* Waters, "Bryozoa from Franz Josef Land," Journ. Linn. Soc., Zool. vol. xxviii. pl. vii. fig. 8 (1900).

† As I have always noticed the articulation when opportunities have presented themselves, several have been carefully figured. In my paper on "Bryozoa from Rapallo," Journ. Linn. Soc., Zool. vol. xxvi. pl. i. the position of the polypides in the zoecia of *Scrupocellaria inermis* is shown, figs. 11, 12, and *op. cit.* vol. xxviii., the joints of *Menipea gracilis*, pl. vii. fig. 12, *Scrupocellaria scabra*, fig. 14, and *S. smittii* Norm., fig. 8, are shown. In the last the articulation only occurs beyond the distal end of the outer zoecium. In the present paper the articulation is shown in Pl. LXVIII. fig. 14.

E.—Lastly, *Menipea cyathus* Wy. Thomp. has only one chitinous tube (Pl. LXIX. fig. 13). In Scrupocellariidæ there is, in some species near the distal end, a long body which may be folded back as in *S. ferax* Aud. (Pl. LXVIII. fig. 14), or it may be very long, extending to the proximal end of the zoecium as in *M. flagellifera* Busk. There is much to suggest that this functions as a testis, and that it should be compared with the organ in *Frustra abyssicola* Sars, and *Cribilina figularis* Johnst.

The classificatory groups may now be considered:—

1. CANDA. Articulation simple as A, p. 473; ovicell smooth, imperforate; vibracula have the setæ serrate. Two vibracula at a bifurcation. Levinsen considers that the ovicell is enclosed in the widened proximal half of the avicularium, whereas I should say that the avicularium is on the ovicell.

2. CABEREA. Articulation internal tubes, ovicell imperforate, vibracula with smooth setæ.

3. SCRUPOCELLARIA (div. 1). Articulation as B, p. 473; ovicell smooth, imperforate, usually with two vibracula at a bifurcation; setæ smooth. This includes *S. delilii* Aud., *S. scruposa* L., *S. scabra* Van Ben., *S. cervicornis* Busk, *S. macandrei* Busk, *S. ornithorhynchus* W. Th., *S. scruposa* var. *dongolensis* Waters. (*S. scabra* has sometimes one vibraculum at a bifurcation.)

4. SCRUPOCELLARIA (div. 2). Articulation as B, p. 473; ovicell perforated, usually one vibraculum at a bifurcation, setæ smooth. This includes *S. bertholletii* Aud., *S. jolloisii* Aud., *S. mansueta* Waters, *S. reptans* L., *S. ferax* Busk, *S. oblecta* Haswell, and probably *S. porteri* MacG., and *S. occidentalis* Trask.

5. BUGULOPSIS. Articulation as C, p. 473; ovicell imperforate, no vibracula. Example, *B. peachii* Busk. I follow Levinsen in using this generic name for the present, but have not had the opportunity of fully studying the genus.

6. MENIPEA (div. 1). Articulation as D, p. 473; ovicell truly endozoecial, showing no external difference, no vibracula; avicularia sometimes suboral and sometimes lateral, short internodes. This includes *M. cirrata* Ell. & Sol., *M. crystallina* Gray, *M. cervicornis* MacG.

7. MENIPEA (div. 2). Articulation as E, p. 474. Two zoecia in an internode, scutum directed downwards from the distal end of the zoecium\*. Possibly a new genus will have to be made for this. This includes *M. cyathus*.

FLABELLARIS. Levinsen leaves in *Menipea* species that cannot be referred to any other of the genera, and puts under it what I

\* Specimens of *Menipea fuagensis* Busk and *M. aculeata* Busk have cases of one zoecium of a new branch growing from the distal end of the terminal zoecium and also one from the side of the lower zoecium.

placed in a new genus *Flabellaris*\*, and I then showed that *Craspedozoum* MacGillivray must be united with one of the types of *Menipea* Lamx., namely *M. flabellum* Ell. & Sol., but it seems better to keep the name *Menipea* for the first species mentioned by Lamouroux, namely *M. cirrata* Lamx. However, this group of *flabellaris* does not seem to belong to the Scrupocellariidae at all, but to the Membraniporidae, having a Membraniporidian ovicell much like that of *M. lineata* L., *M. craticula* Alder, *M. unicornis* Flem. The species included are *F. flabellata* Ell. & Sol., *F. (M.) cuspidata* Busk (Pl. LXIX. fig. 9), *F. triseriata* MacG. (specimens in my collection have ovicells), *F. ("Craspedozoum") roborata* Hincks, *F. (C.) ligulatum* MacG., *F. multiseriata* Busk. *F. roborata* and *F. ligulatum* when broken through have at the articulation interior tubes like the radicles.

The ovaria of *Flabellaris roborata* are distal with many ovarian cells, and one or more grow to a considerable size. Jullien† considered that *Menipea* must be merged in Scrupocellaria in consequence of having found one vibraculum on *Menipea clausa* Jull. = *Scrupocellaria marsupiata* Busk, and this conclusion he considered was upheld by the fact that some colonies of *S. scabra* Van Ben. have no vibracula, while others have a few or sometimes many. This seemed quite reasonable, and since then the idea has received further support, as Levinsen has found one vibraculum on *M. ternata*, and, also, he found vibracula on *Menipea benemunita* Busk of the 'Challenger,' for which Levinsen proposed the genus *Caberiella*. Also, the form and position of the radicle chamber in *Scrupocellaria serrata* Waters‡ suggests that a recent ancestor had vibracula.

Although these cases prove that the presence of vibracula does not give a sharp divisional line between what has been understood as *Scrupocellaria* and *Menipea*, yet all the species could scarcely remain in one genus, and separation can be made on other grounds. The presence of avicularia gives but very limited assistance in classification, although there are characters in the avicularia which are very useful; so it is, therefore, not surprising to find that in some species vibracula may be found as an exception.

Most of what have been called *Menipea* have an anterior avicularium immediately below the area or slightly to one side, though there are some species without any, as *S. inermis*, nor are lateral avicularia universal.

Levinson§ considered that *Caberea* and his *Caberiella* had the avicularium divided into two chambers, whereas I was unable to find two, for while there is a prolongation of the vibracular chamber, this only seems to be for the groove in which the

\* Waters, "On Membraniporidae," Journ. Linn. Soc., Zool. vol. xxvi. p. 672, pl. xlviii. figs. 10, 11; xlix. figs. 7-10 (1898).

† 'Cap Horn,' p. 69 (1888), and Bull. Soc. Zool. de France, p. 507 (1882).

‡ Report on Red Sea Bryozoa, Journ. Linn. Soc., Zool. vol. xxxi. p. 133, pl. x. figs. 11-14 (1909).

§ Morph. and Syst. Studies on the Cheil. Bryozoa, p. 134.

vibracular seta lies. Exactly the same thing, though not so marked, is seen in *Scrupocellaria*, for in several species the vibraculum extends beyond the median line, as in *S. macandrei* Busk, *S. incurrata* Waters, etc.

As I told Dr. Levinsen that I did not find two chambers, he kindly sent me some vibracula, skilfully separated, which, however, only confirmed what I had seen in my own specimens.

In the Scrupocellaridæ, so far as I have seen, the ovaria are large, situated near the distal end, and contain several ova which are developed into large ova before they pass into the ovicell. On the other hand, in *Bugula*, *Bicellaria*, etc., the ovaria are, at the proximal end, usually very near to the base of the cæcum; they are very small with usually two small ova, and when still extremely small, an ovum passes into the ovicell. It is very interesting to find these generic differences in the ovaria, and undoubtedly the form, size, and position of the ovaria will be found to furnish useful characters in many species of Bryozoa.

The direction of evolution of the Scrupocellaridæ seems to be indicated in the articulation, and a comparison of the changes in this family may help us to understand the Catenicellidæ better.

SCRUPOCELLARIA FEROX Busk. (Pl. LXVIII. figs. 11-15; Pl. LXIX. figs. 7, 20.)

*Scrupocellaria ferox* Busk, B. M. Cat. Mar. Polyzoa, p. 25, pl. xxii. figs. 1, 2, & 5.

The avicularia vary considerably in size, being largest just below a bifurcation, and smallest or wanting in the younger zoecia. The avicularian chamber has the lateral projection to which I referred and figured in *S. mansueta* Waters\*, from the Red Sea, and the long dorsal opening of the vibracular chamber in the older zoecia has a calcareous band across dividing it in two (see fig. 14). There is one vibraculum to a bifurcation somewhat directed towards the front, as in *S. cyclostoma* Busk, and the radicle, which is hooked at the end, is not ringed as in *S. cyclostoma*, but there are only a few complete radicles in the specimens. No ovicells occur on the Zanzibar specimens.

There are about 24 tentacles.

The rosette-plate into the vibracular chamber is at the base of the chamber and has many pores; as this rosette-plate is not always very distinctly marked off these pores might be looked upon as several plates. Each zoecium has its own lateral wall, so that when prepared in Eau de Javelle they may separate. Stained preparations show a band near the distal end bent back upon itself (fig. 12b). The contents are granular, with hollow places at intervals, and probably the function is the same as in the bodies† I mentioned in *Bugula bicornis* Busk‡, and they

\* Journ. Linn. Soc., Zool. vol. xxxi. p. 134, pl. x. fig. 15 (1909).

† Those on page 474 are compared with somewhat similar structures in *M. flagellifera* B., *Flustra abyssicola* Sars, and *Cribrilina figuraris* Johnst.

‡ Résult. du Voyage S.Y. Belgica, "Bryozoa," p. 21, pl. i. fig. 4 (1904).



are probably testes, or connected with the testes, and in all the specimens prepared these bands are found in all the zoecia, but there are no traces of ovaria, so it may be that the male organs are on one colony and the female on another.

In one mount with about 130 zoecia all contain fully developed polypides, showing that degeneration does not always take place at such short intervals as has been often stated. There are, however, large buds developing by the side of the active polypides.

*Loc.* Louisiade Archipelago, Bass's Straits (*B.*). Prison Island, Zanzibar Channel (505), 8 fath.; Ras Osowamembe, Zanzibar Channel, 10 fath. (504 & 514); Wasin, Brit. E. Africa, 10 fath. (507), collected by Crossland.

Other species of tropical *Scrupocellaria*, not however found in the Crossland collections, are *S. delilii* Aud.; *S. ornithorhynchus* B.; *S. ciliata* Aud.; *S. annectans* MacG.; *S. diadema* B.; *S. minuta* Kirkp.; *S. clypeata* Hasw.; *S. obtecta* Hasw.

SCRUPOCELLARIA CERVICORNIS Busk. (Pl. LXIX. figs. 3, 4.)

Waters, "Rep. Sudanese Red Sea," p. 166.

*Loc.* add Ras Osowamembe, 10 fath. (504); Wasin, Brit. East Africa, 20 fath. (522), collected by Crossland.

SCRUPOCELLARIA MACANDREI Busk. (Pl. LXVIII. figs. 5, 6.)

*Scrupocellaria macandrei* Busk, B. M. Cat. Mar. Polyzoa, p. 24, pl. xxiv. figs. 1-3; and add to Miss Jelly's synonyms:—Haswell, W. A., "Polyzoa from the Queensland Coast," Proc. Linn. Soc. N. S. Wales, vol. v. p. 37; Philipps, "Rep. on the Polyzoa," Willey's Zool. Results, pt. iv. p. 442 (1899); Calvet, 'Exp. Scient. du Travailleur et du Talisman,' p. 375 (1907); Thornely, "Mar. Polyzoa of the Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 140 (1912).

This belongs to the *S. scruposa* group. There are three outer spines and one inner near the peduncle of the scutum. The outer spines are often very long. The groove of the vibraculum is continued beyond the vibracular chamber, passing the median line of the zoecium, in this respect somewhat resembling *S. incurvata* Waters. There are two vibracula at a bifurcation. The ovicell is smooth, placed somewhat diagonally, and has a clear space on the front. The vibracular seta is about the length of a zoecium, smooth but flat in the middle, so that perhaps we may call it sickle-shaped. The oral aperture is placed diagonally back, as in *Caberea darwini* Busk.

*Loc.* Cape Verde Island, 1070-1150 fath. (*B.*) & 110-180 met. (*Calv.*) & Crossland Expedition; St. Paul's Rocks, N. Atlantic (*B.*); Coast of Spain (*B.*); Adriatic (*Heller*); Lifu (*Phil.*); Queensland (*Haswell*); Providence, 50-78 fath., Amirante, 29 fath., Farquhar Reef, Cargados, 30 fath., and Seychelles, 34 fath.

(Ind. Ocean, *Thornely*). Prison Island, Zanzibar Channel (505), 8 fath., coll. by Crossland.

SCRUPOCELLARIA PILOSA Savigny & Audouin (*non* Busk). (Pl. LXVIII. figs. 3, 4.)

*Crisia pilosa* Aud. Description de l'Égypte, Hist. nat. p. 241; Savigny's pl. xii. figs. 1<sub>1</sub>-1<sub>5</sub>.

*Cellularia spatulata* d'Orb. Pal. Franç., Terr. Crét. p. 50 (1850-52).

Some dried specimens from Wasin, B. E. Africa, seem to be the species figured by Savigny. The zoecia are narrow, producing a wavy appearance, as figured by Savigny. The opesium has a very narrow border, and the scutum, which varies in shape, is small and does not nearly cover the aperture. Both the distal and proximal ends of the scutum are rounded, with the distal end the larger, and the scutum is without cervicorn marks. There are two or three oral spines on the outer side and one or two on the inner, the outer ones, especially the lower one, which is stouter, are sometimes long, though in the specimens they are mostly broken off. The vibraculum is small, partly free at the outside of the zoarium, with the groove extending slightly beyond the vibracular chamber, but not as much so as in *S. macandrei* B. The vibracular setae are smooth and rather longer than a zoecium. The zoarium at a bifurcation has a medium spine and one vibraculum. The lateral avicularium is placed somewhat diagonally, instead of standing straight out. The radicles are large and are serrate near the ends.

There are no ovicells on the specimens.

Busk in the 'Challenger' Report, p. 24, describes a species from the southern hemisphere as *S. pilosa* Sav., but this seems a doubtful determination, for the shape of the scutum is different and the vibracular chamber is very wide and large.

Busk speaks of it as the species of Audouin, whereas Audouin calls it the species of Lamouroux, and supported the identity on Lamouroux having presented some of the type to M. Bory de St. Vincent which was compared. However, it was never the species of Lamouroux but of Pallas, and while his description would tally with this species, it would equally well cover a large number of other *Scrupocellariae*. D'Orbigny gave the name *spatulata* to Savigny's figure, and in the same way he named many of Savigny's other figures, although already named by Audouin. Savigny having given recognisable figures, we may suppose that Pallas and Lamouroux were dealing with the same thing, although this can never be known with certainty.

This is much like *Scrupocellaria pusilla* Smitt, which, however, has cervicorn markings on the scutum.

The various species now considered might well be ranged round *S. scruposa* as varieties.

*Loc.* ? Mediterranean (*Pallas*, etc.). Wasin, Brit. East Africa, 10 fath. (500), collected by Crossland.

*SCRUPOCELLARIA WASINENSIS*, sp. n. (Pl. LXVIII. figs. 9, 10; Pl. LXIX. figs. 17-19.)

Zoarium usually with 5 or 7 zoecia in an internode. Zoecia wide, with the round area occupying more than half the length of the zoecium; at the distal end there are three exterior spines and one interior; the anterior avicularia are medium-sized, raised, tubular, with a narrow triangular mandible; the lateral avicularia are very small; the vibraculum, together with the radicular chamber, is about half the length of a zoecium, the delicate vibracular setæ are smooth and slightly longer than a zoecium; the vibracular chamber is separated near the base from the radicular chamber, and the distal end is contracted. There is one vibraculum at a bifurcation. A few large lateral avicularia have been seen which are divided at the end, and the mandible is forked like that of *S. serrata* Waters\*.

The globular ovicell has numerous pores.

The radicles sometimes pass from one branch to another, as in *Caberea retiformis* Sm.

There are about 16 tentacles.

The ovaries containing many ova are at the distal end, while testes in the same zoecia are at the proximal end. The ovaria in *Scrupocellaria* contain several ova, but the ovaria in this species are peculiar, as there are at first a number of large homogeneous cells of which usually only one or two show any nucleus (Pl. LXIX. fig. 19). The ovaria at this stage show no follicular wall, but at a later stage, when the yolk-mass of an ovum has become very large, then the follicular wall is distinct.

In this species, as in other *Scrupocellariae*, a large ovum passes into the ovicell, whereas in *Bugula* the ovaria instead of being distal are proximal, and a small ovum in a very early stage passes into the ovicell†. The ovarian cells, which are frequently far apart, are often surrounded by a protoplasmic network which passes up to the rosette-plate of the next zoecium (figs. 18, 19). This species is of about the same size as *S. mansueta* Waters, but has four distal spines and a much smaller vibraculum, with setæ more delicate, and about half to one-third the length of the latter form. The large lateral avicularia are known in *S. varians* Hincks, *S. serrata* Waters, and *S. oblecta* Haswell, but apparently are only the ordinary avicularia more developed.

*Loc.* Wasin, Brit. East Africa, 20 fath. (522), collected by Crossland.

*CANDA RETIFORMIS* Pourtales. (Pl. LXIX. figs. 1, 2, 6.)

*Canda retiformis* Pourtales, Bull. Mus. Comp. Zool. Harvard Coll., I., No. 6, p. 110 (1867); Philipps, "Rep. on Polyzoa," Willey,

\* "Bryozoa of Sudanese Red Sea," Journ. Linn. Soc., Zool. vol. xxxi. p. 133, pl. x. fig. 11.

† In *Bugula* there are two small ova in each ovarium, occasionally three, or even four, small ones; however, in *B. murrayana* Johnst., now called *Dendroboeana* by Levisen, the ovarium is distal, and the ova in the ovarium grow to a large size, so that the material differences in the ovaria would alone suggest that *murrayana* does not belong to the same genus as *B. avicularis*, etc.

Zool. Results, pt. iv. p. 441, pl. xlii. fig. 1 (1899); Thornely, "Mar. Polyzoa of the Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 141 (1912).

*Caberea retiformis* Smitt, "Floridan Broyzoa," pt. i. p. 16, pl. v. figs. 43-46 (1872); Thornely, "Ceylon Pearl-Oyster Fisheries," vol. iv. Suppl. Rep. xxvi. p. 109 (1905).

? *Canda fossilis* Waters, Q. Journ. Geol. Soc. vol. xxxvii. p. 322, pl. xvi. figs. 51, 52 (1881); MacG. "Tert. Polyzoa of Victoria," p. 25, pl. iii. figs. 12-14, Trans. R. Soc. Vict. vol. iv. (1895).

The specimens from Zanzibar have the scutum very narrow, pointed distally, and rounded proximally, as described by Miss Philipps, and I follow her in considering them to be the form described by Smitt, and although allied to *C. arachnoides* they seem quite distinct. It occurs in the Atlantic, the Indian Ocean, and the Loyalty Islands, without any connecting links being known. *Caberea crassimarginata* B., of the 'Challenger,' and *Scrupocellaria clypeata* Haswell, seem to belong to this group.

No anterior avicularium has been described, but sometimes there is one attached to the inner side of the zoecium, and then it is usually just below a bifurcation. The avicularian chamber is wide, and the mandible is triangular. There are two vibracula at a bifurcation.

Both Smitt and Levisen have considered this species as having no articulation, and as the chitinous tube is often entirely covered by the calcareous wall in which there is as yet no rupture, it requires decalcification to study the articulation, which is peculiar and seems to differ from that of any other species examined. In the younger branches there is no sign of articulation, but in the older ones there is one chitinous tube on the inside of *one of the two* branches, but not of both, and a point to be noticed is that when the chitinous tube is on one side, say to the right, it is in the next branch on the left, in the one following on the right, and so on alternately, though in a few cases in the older parts of the colony I have seen a chitinous tube to each branch. In *C. arachnoides* Lamx., as I have shown\*, there are two chitinous tubes, one on the inside of each branch. The articulation of *C. tenuis* MacG. is somewhat similar.

When decalcified, a chitinous tube is shown in the peduncle of the scutum, just as is seen in the base of many spines.

Near the base of the vibracular seta there is a projecting delicate free arch at right angles to the axis of the seta, and in other species of the Scrupocellaridæ there seems to be a similar structure, though not so pronounced.

One of the cross radicle tubes usually connects the two new branches at a very short distance from the bifurcation, and this may partly account for rupture at the articulation so seldom taking place (see fig. 1).

\* Ann. Mag. Nat. Hist. ser. 5, vol. xx., p. 89, pl. iv. fig. 7.

There are about 16 tentacles.

The vibraculum of *Canda retiformis* is of the same character as that of *Scrupocellaria*, in which genus some of the vibracular chambers extend beyond the median line of the zoarium, though not quite as much so as in the two species of *Canda*; also the vibraculum of *Caberea* has the same general character.

I have several times maintained\* that there are material differences between avicularia and vibracula, but that the length of the mandible or seta is of no importance in indicating which they are. The distinctions are in the chamber and the basal part of the chitinous organs. While the mandibles of avicularia are symmetrical and have the closing muscles attached by †one or two long tendons, the base of asymmetrical seta of the vibracula is very complicated with a large number of curiously shaped protuberances, to some of which the muscles are attached by a fascia, but without any long tendon, so that instead of there being two main muscles, there are more attached by a short band to various parts of the base of the seta. The vibracular base is very small, so that it is difficult to follow this complicated mechanism; the reason for this complication is found in the seta being movable in all directions, whereas the mandibles of the avicularia only move in one. The mandibles all have a straight proximal edge, but this is not the case in the seta; further, the avicularian mandible works from this straight base either against the calcareous bar, or, in case this is not complete, then from two teeth. The universal movement could not take place with a cross-bar, and none has been found, nor must we ever expect to find one in vibracula. The vibracular chambers of this group are different from those of *Cupularia*‡, etc., in which the vibracular chamber takes the place of a zoecium.

*Loc.* Florida, 68 & 270 fath.; Loyalty Islands (*Ph.*); Galle, deep water (*Th.*); Amirante, 23-29 fath., Saya de Malha, 55 fath., Seychelles, 39 fath., Cargados, 30 fath. (*Thornely*). Wasin, Brit. East Africa, 10 fath. (501); Prison Island, Zanzibar Channel (505), 8 fath., Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

#### CATENARIA LAFONTII Audouin.

Waters, "Rep. Sudanese Red Sea," p. 131.

Near the distal end there are small ovaria with two ovarian cells.

*Loc.* Wasin, Brit. East Africa, 10 fath. (501); Prison Island, 8 fath.; Chuaka, 2 fath. (508), 3 fath. (526); Meweni Bay, 6 fath. (510); Zanzibar town, shore (527).

\* Résultats du Voyage du S.Y. Belgica, "Bryozoa," p. 27. Zool. Chall. Exp. vol. lxxix. p. 22, pl. i. fig. 12.

† See page 529.

‡ Very minute glands occur in the vibracula of *Cupularia*.

CATENARIA DIAPHANA Busk. (Pl. LXIV. figs. 6-11.)

*Scruparia diaphana* Busk, Q. J. Micr. Sc. vol. viii. p. 281, pl. xxxi. fig. 1 (1860).

*Catenaria diaphana* Busk, "Polyzoa," Zool. Chall. Exp. vol. x. pt. xxx. p. 14, pl. ii. fig. 3 (1884).

*Halysis diaphana* Norman, "Polyzoa from Madeira," Journ. Linn. Soc., Zool. vol. xxx. p. 296 (1909); Levinsen, Morph. & Syst. Studies on Cheil. Bryozoa, p. 274 (1909).

The ovicell has not before been described, in fact Levinsen says it is wanting. A growth of the outer calcareous wall of this recumbent ovicell projects forward from the distal end in the middle and also from the sides, forming at first one elongate space which is subsequently divided, making two vacant spaces or large pores. The node with an ovicell or ovicells is never a single zoecium, and there are often many zoecia with ovicells in a node (fig. 9); six together have been counted many times. We have seen many ovicelligerous zoecia in a node in Catenicellidæ. The node may, however, be only one ovicelligerous zoecium followed by an ordinary zoecium. As a rule, from the distal end of the older zoecium a new zoecium arises in the median line, and there may also be one growing laterally from very near the end, or occasionally one on each side.

The front wall is but little raised and is perforated, the perforated part being bounded on each side by a raised ridge, and on the dorsal surface there are two lines of pores. The parietal muscles start under the longitudinal ridge. The operculum has a dark mark in the proximal part (fig. 8), and there are 20-22 tentacles. There are radicles attached to the side of the zoecium, with the attachment elongate in the direction of the long axis. None of the ovaria seen in sections are surrounded by the follicular cells occurring in nearly all species. The ovarium (fig. 10), with many ovarian cells, is found near the basal wall, a short distance below the ovicell. The ovum is seen in the upper part of the zoecium, where there are strong muscles ready to force it into the ovicell from below internally, and sometimes there is an embryo or ovum in the ovicell as well as a large ovum below in the zoecium. Levinsen\* considers that in some species of Bryozoa the ovum comes out of the zoecium and then enters the ovicell, but until proof is brought forward we may hold a position of doubt, as the contrary is known in so many cases.

All the characters given by Norman for his genus *Halysis* apply to *Catenaria lafontii* Aud., and it is not clear that a new genus is required. Levinsen makes the absence of the avicularia and of ovicells a reason for separating this species from his genus *Savignyella* = *C. lafontii* Aud., but in a large proportion of genera there is sometimes an avicularium, sometimes none. The genus *Catenaria* was discussed in my Report on the Sudanese Bryozoa†.

\* Loc. cit. p. 67.

† Journ. Linn. Soc., Zool. vol. xxxi. pp. 130, 131 (1900).

*Loc.* Madeira (B.); St. Paul's Rocks, N. Atlantic (*Challenger*), shallow water. Ras Osowamembe, Zanzibar Channel, 10 fath. (504); Prison Island, Zanzibar, 8 fath. (505), collected by Crossland.

#### CATENICELLIDÆ.

In the Catenicellidæ the ovicells are of much more use in classification than has been generally recognised, but Levisen has ignored them in his synopsis of the genera, nor has he used the shape of the opercula.

Based upon the form of the ovicells, there are two main divisions:—

FIRST, those in which the ovicell is a terminal gonœcium, as *Scuticella* Lev., *Costaticella*\* Maplestone, *Cribricella*† Lev., all three of which have an operculum with a straight or but slightly curved edge, and *Calpidium*, which has a sinus. In all these genera the ovicelligerous zoœcium has a much wider operculum than the ordinary zoœcium, but the proximal edge is straight, although in both the gonœcium of all of these, and the ordinary zoœcium of the first three, there may be an apparent sinus in the calcareous wall.

SECOND, those in which the ovicell occurs in a node with other zoœcia; divided into

I. Species with the ovicell occurring between two zoœcia in a straight line and the operculum straight or nearly so on the proximal edge; and here we have *Vittaticella*‡ Maplestone, in which the ovicell is partly imbedded in the superior zoœcium and is surrounded by a beaded structure; also *Catenicella delicatula* Wilson and *Claviporella pulchra* MacG. have the ovicell in the same position but perforated all over. Perhaps a new genus is required for these two, and *C. umbonata* § B. may have to be included.

II. Species with the tuberculate imperforate ovicell at the end of a mother zoœcium of a biglobulus, namely, *C. perforata* B., *C. taurina* B., *C. cornuta* B., but very few ovicells have been seen in this group, and perhaps it is a matter of secondary importance whether they are on a biglobulus or a triglobulus.

III. Species with the ovicell belonging to the mother zoœcium of a triglobulus, including *Pterocella* Lev., which has a double area to the ovicell and the ovicelligerous aperture different from those of the ordinary zoœcia; *Strongylopora* || Maplestone, with a perforated ovicell and the operculum straight at the proximal edge

\* "Further Desc. of the Tert. Polyzoa of Victoria," Proc. Roy. Soc. Vict. vol. xii. n. s. p. 9 (1899). Levisen, in making the genus *Costicella*, evidently overlooked the fact that Maplestone had already made a genus *Costaticella*, of which the type was *lineata*, a species included by Levisen in his *Costicella*.

† As indicated in the 'Zoological Record,' the name *Cribricella* has already been used by Canu for a fossil belonging to the family Adeonidæ.

‡ The surface of none of the *Vittaticella* seem to be perforate, but smooth or papillose, but some have wrongly been described as perforate.

§ Described as *fusca* by MacGillivray.

|| This Levisen calls *Hincksiella*, but Maplestone has priority, as his genus was described in 1899 (Proc. Roy. Soc. Vict. vol. xii. p. 4).

of both the ordinary zoëcia and the ovicelligerous zoëcia, although the notch in the calcareous wall has been taken for an oral sinus; *Claviporella* Lev., with a perforated ovicell and triangular aperture to both forms of zoëcia.

The characters relied upon by Levisen are none of them now mentioned, as my object is to show the importance of the ovicell and of the operculum in classification, though of course all available characters must be used.

Levisen (p. 254, pl. xiii.) mentions a closure in *Vittaticella* and other genera which he calls an "occlusion." I have not seen anything quite like Levisen's description, in which it is said to start from three processes, which, of course, is the youngest stage, but in a specimen of *Catenicella cornuta* B. from Western Port, Victoria, there is in the older zoëcia a calcareous closure which is, however, under the operculum and quite independent of it. There are two round openings near the distal end, that is, one at each side, and a rather larger one at the proximal end. In a few very old zoëcia these two distal pores coalesce and the proximal opening becomes much larger, as if it were being dissolved away. I have only been able to find this closure in *C. elegans*, in var. *zanzibariensis*, nov., and in *C. cornuta* as mentioned, although I have looked through the Catenicellidæ in my collection and the British Museum, though Levisen gives it as a character of *Vittaticella* (*Catenaria* Lev.). However, it only occurs in the older and empty zoëcia, and now, knowing this, I might on re-examination find some which had been overlooked. On p. 505 it is suggested that certain closures of Meliceritidæ should be compared.

*VITTATICELLA ELEGANS* Busk. (Pl. LXV. figs. 1-7, 12.)

*Catenicella elegans* Busk, Brit. Mus. Cat. Mar. Polyzoa, p. 10, pl. ix. (1852); Zool. Chall. Exp., Polyzoa, vol. x. pt. xxx. p. 12 (*pars*); Ortmann, "Die Japanische Bry.," Arch. für Naturgesch. vol. i. p. 27 (1890); MacGillivray, Prod. Nat. Hist. Vict. dec. iii. p. 23, pl. xxiv. fig. 10 (1895); Thornely, Ceylon Pearl-Oyster Fisheries, Suppl. Rep. xxvi. p. 109 (1905).

*Vittaticella elegans* Maplestone, "On a new name—*Vittaticella*—for the Polyzoon genus *Caloporella* McG.," Proc. Roy. Soc. Vict. vol. xiii. n. s. p. 203 (1900).

Specimens from Zanzibar growing on seaweed seem to be this species. There is sometimes on one side of the zoëcium a very long, raised avicularium with the mandible directed distally (figs. 1, 2). A similar avicularium occurs in a specimen in the British Museum from Arafura Sea. On the dorsal surface there are the two small dots as figured by me in *Vittaticella contei* Aud. (also in *Brettia*), and the radicles are in the same position as in *V. contei*. In one case a new zoëcium springs from the anterior surface of an older zoëcium, and this I have seen in other species of *Vittaticella*.

The operculum is larger than that of *V. contei*, and is more



curved on the proximal edge; on the other hand, it is not so large as that of *V. buskei* W. Th. These are all nearly related, but the difference in the operculum and the number of tentacles, besides other characters, indicate that they must be separated.

There are often many ovicelligerous zoecia in one node. In one specimen there are two cases of a node having six ovicelligerous zoecia in one continuous line, and in both cases a lateral zoecium grows from the side of the unjointed node. In the ovicelligerous zoecia the avicularia near the oral aperture are directed forwards instead of laterally, as in the other zoecia. In the Tertiary beds of Curdies Creek, Australia, there is a form with long biserial nodes which I described as *Catenicella internodia*\*, but for which MacGillivray has since made the genus *Ditaxipora*; also from the North Italian tertiaries I have described two forms with long biserial nodes as *C. septentrionalis*† and *C. continua*, of which *continua* is probably *Vittaticella*, but *septentrionalis* will require a new genus, so far as we can see at present.

Among recent forms no long nodes have previously been described, but in the specimen from Madeira, which Norman considered to be *C. contei* Aud., there are two zoecia with ovicells following one another in an internode. Long ovicelligerous nodes are also found in *Catenaria diaphana* B. (see p. 482).

The ovaria commence at the proximal end at one side, whereas the testes are near the distal end to one side. There are ciliated embryos in the ovicells, and below the ovicells there are several fleshy bands or tubes by which, no doubt, material for growth is transferred to the ovicell.

*Loc.* Bass's Strait, 47 fath., Banks' Peninsula, Algoa Bay, Port Dalrymple; Tasmania (*B.*), Victoria (*MacG.*); Sagami-bai, Japan (*Ort.*); Gulf of Manaar, on floating oyster-cages (*Th.*); Arafura Bay (*Brit. Mus.*). Prison Island, Zanzibar shore (503); Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

*VITTATICELLA ELEGANS*, var. *ZANZIBARIENSIS*, nov. (Pl. LXV. figs. 8-11.)

Zoarium about 40 mm. high, with the branches curved over. Zoecia elongate ovoid, surface smooth or slightly papillose; large lateral avicularia with a large pore at the base, in this respect differing from the type. There are on the dorsal surface near the distal end, and often resting on the large avicularia, two minute oval avicularia or an oval raised tubular opening. The radicles arising from the dorsal surface form a thick bundle.

No ovicells are known.

It is very similar to *V. elegans* B., but the larger beaked

\* "Foss. Chil. Bry. from S.W. Victoria," Quart. Journ. Geol. Soc. vol. xxxvii. p. 318, pl. xvi. figs. 78, 79 (1881).

† "North Italian Bryozoa," Quart. Journ. Geol. Soc. vol. xlvii. p. 5, pl. i. figs. 1-8 (1891).

of both the ordinary zoëcia and the ovicelligerous zoëcia, although the notch in the calcareous wall has been taken for an oral sinus; *Clarioporella* Lev., with a perforated ovicell and triangular aperture to both forms of zoëcia.

The characters relied upon by Levinsen are none of them now mentioned, as my object is to show the importance of the ovicell and of the operculum in classification, though of course all available characters must be used.

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The operculum is larger than that of *V. contei*, and is more

curved on the proximal edge; on the other hand, it is not so large as that of *V. buskei* W. Th. These are all nearly related, but the difference in the operculum and the number of tentacles, besides other characters, indicate that they must be separated.

There are often many ovicelligerous zoecia in one node. In one specimen there are two cases of a node having six ovicelligerous zoecia in one continuous line, and in both cases a lateral zoecium grows from the side of the unjointed node. In the ovicelligerous zoecia the avicularia near the oral aperture are directed forwards instead of laterally, as in the other zoecia. In the Tertiary beds of Curdies Creek, Australia, there is a form with long biserial nodes which I described as *Catenicella internodia*\*, but for which MacGillivray has since made the genus *Dilatæipora*; also from the North Italian tertiaries I have described two forms with long biserial nodes as *C. septentrionalis*† and *C. continua*, of which *continua* is probably *Vittaticella*, but *septentrionalis* will require a new genus, so far as we can see at present.

Among recent forms no long nodes have previously been described, but in the specimen from Madeira, which Norman considered to be *C. contæi* Aud., there are two zoecia with ovicells following one another in an internode. Long ovicelligerous nodes are also found in *Catenaria diaphana* B. (see p. 482).

The ovaria commence at the proximal end at one side, whereas the testes are near the distal end to one side. There are ciliated embryos in the ovicells, and below the ovicells there are several fleshy bands or tubes by which, no doubt, material for growth is transferred to the ovicell.

*Loc.* Bass's Strait, 47 fath., Banks' Peninsula, Algoa Bay, Port Dalrymple; Tasmania (*B.*), Victoria (*MacG.*); Sagami-bai, Japan (*Ort.*); Gulf of Manaar, on floating oyster-cages (*Th.*); Arafura Bay (*Brit. Mus.*). Prison Island, Zanzibar shore (503); Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

VITTATICELLA ELEGANS, var. ZANZIBARIENSIS, nov. (Pl. LXV. figs. 8-11.)

Zoarium about 40 mm. high, with the branches curved over. Zoecia elongate ovoid, surface smooth or slightly papillose; large lateral avicularia with a large pore at the base, in this respect differing from the type. There are on the dorsal surface near the distal end, and often resting on the large avicularia, two minute oval avicularia or an oval raised tubular opening. The radicles arising from the dorsal surface form a thick bundle.

No ovicells are known.

It is very similar to *V. elegans* B., but the larger beaked

\* "Foss. Chil. Bry. from S.W. Victoria," Quart. Journ. Geol. Soc. vol. xxxvii. p. 318, pl. xvi. figs. 78, 79 (1881).

† "North Italian Bryozoa," Quart. Journ. Geol. Soc. vol. xlvii. p. 5, pl. i. figs. 1-8 (1891).

avicularium with the large pore at the base and the minute dorsal avicularia suggest its being separated as a variety.

The structure of the vittæ has not received much attention, though Harmer\* has alluded to it; but in this species it has been possible to obtain some explanation. The vittæ are sunken perforated grooves in the calcareous wall, and along each groove there is a cylindrical tube, and within this, from the pore-tubes (the perforations just mentioned), organic cords spread out and reach the upper free surface at definite spots or pores (fig. 10). It thus seems that the vittæ should be compared with pore-chambers of many Cheilostomata in so far as there is indirect communication from the interior to the water-surface, through the vittæ.

*Loc.* Prison Island, Zanzibar Channel, 8 fath. (505); Wasin, Brit. East Africa, 10 fath. (500), collected by Crossland. Algoa Bay and Natal (*Brit. Mus.*).

MEMBRANIPORA SAVARTII Audouin. (Pl. LXXI. figs. 1-4.)

In my Report on the Bryozoa from the Red Sea (Journ. Linn. Soc., Zool. vol. xxxi. p. 138), I refer to the astonishing amount of anastomosing protoplasmic threads in a specimen from Zanzibar, and as some from the Sudan are also very full, this seems to be a specific character. It certainly seems strange to find such an extraordinary quantity, for though in my collection there are preparations of a large number of species showing the threads exceedingly well, I have never seen anything approaching these, and further study of the funicular cords is desirable.

These threads are very abundant in zoecia with active polypides having digestion in full activity. In these threads are included small granular patches, either round or filiform, and where the polypides have degenerated or are degenerating there are large masses of this granular substance also surrounded by and connected with the protoplasma (fig. 2). In earlier stages the protoplasmic threads are in some cases surrounding the granular cord (fig. 4); in others there are only one or two plasmic threads by the sides of the granular cord or mass.

The collecting together of these masses naturally suggests that waste products are thus brought together and afterwards got rid of.

*Loc.* Zanzibar Channel from the under side of buoy (528); Ras Osowamembe, Zanzibar Channel, 10 fath. (504); Prison Island, Zanzibar Channel, 8 fath. (505), collected by Crossland.

?MEMBRANIPORA ARMATA Haswell (*non* Koschinsky). (Pl. LXVII. fig. 10, & Pl. LXXI. figs. 5-10.)

*Biflustra armata* Haswell, "On some Polyzoa from the Queensland Coast," Proc. Linn. Soc. N. S. Wales, vol. v. p. 38, pl. i. fig. 7 (1880).

\* "Morph. Cheil.," Quart. Journ. Micr. Sc. vol. xli. p. 306 (1902).

*Membranipora panhoplites* Ortmann, "Die Japan. Bry.," Arch. Naturgesch. vol. i. p. 28, pl. ii. fig. 4 (1890).

*Membranipora armata* Waters, "On Membraniporidae," Journ. Linn. Soc., Zool. vol. xxvi. p. 687, pl. xlvii. fig. 3 (1898).

The specimen from Wasin is in parts in the hemescharan stage, in others in the bilaminar, and one in my collection from Port Molle is also bilaminar. This specimen from Wasin starts from a unilaminar incrusting layer, but in places the zoarium is tubular.

The distal wall of the zoecium is slightly prominent, somewhat reminding us of what Busk calls the penthouse projection in *Aspidostoma giganteum* B. There are no ovicells in any of the specimens examined, and on most of the zoecia an avicularium occurs on one side only, at the distal end, directed proximally, while on the other side, in a long chamber, there is a long gland with distinct secreting cells (figs. 8, 9), but usually without any lumen. These glands are irregular in shape, sometimes lobed, and there may be two elongate lobes side by side. In all the specimens seen there is a distinct calcareous bar or arch to the avicularium, and there are two openings on the front of the avicularium, though sometimes the lateral projections in the avicularium do not meet, when there is, consequently, only one opening (fig. 7). In the membrane covering the avicularian chamber there is, under the mandible, a chitinous ring where the peculiar body\* ends (fig. 9, *pb.*), and there are other species of Cheilostomata with a chitinous ring or other thickening. As we have seen, there is at one side an extremely long avicularian chamber, at the proximal end of which there are stout muscles (fig. 9 *a*) attached to a very long tendon by which the mandible is closed; further up there are muscles also on both sides of the chamber, but much more delicate than the last (fig. 9 *b*), and attached to a shorter tendon fastened to the base of the mandible with a median attachment, whereas in some species of Cheilostomata this muscle is attached at each side.

The chamber containing the glands (fig. 9, *gc.*) is also very long, and may be close to the avicularian chamber of the zoecium next above or below, but no connection with the avicularia has been found after careful examination of many microtome sections. On the inside there are pores like rosette-plates, and the protoplasmic threads from these are sometimes seen passing to the gland, but no other internal opening has been found. Externally there are three or four minute pores along the line of junction of the zoecia, which, however, were only noticed when carefully searching for openings. There are similar small pores over the avicularian chamber. We have here another Bryozoan puzzle, for the gland is not the same as the oral gland, and is contained in a calcareous chamber without any openings except small pores.

\* This peculiar body is in many Cheilostomata contained in a sheath, homologous with the tentacular sheath, but in this species no sheath was found.

The operculum is membranous, with a diagonal band or sclerite on each side to which the muscle for closing the operculum is attached; but also attached to the same sclerite there is a muscular band fastened to the tentacular sheath. I have not noticed a double attachment like this before, but examination may show that it occurs in other species.

In a large proportion of zoecia there are two polypides of about the same size, so that 20-30 zoecia with two polypides may be seen adjoining one another, whereas other pieces may show a much more limited number of double polypides. Although budding polypides in the same zoecia as mature polypides are known to us all, and have been described by Haddon\*, Ostromoff†, and Harmer‡, they are only in a limited number of zoecia; nor have I been able to see that they are the same as the two zoecia described by Prouho § in *Alcyonidium duplex* P. The two tentacular sheaths are side by side, and are attached to the operculum and the neighbouring wall. No ovaria or ova have been seen, and only in a very few cases were testes found occurring in round masses near the lateral wall.

From the lateral walls there are bundles of muscles (6-12) attached to the frontal membrane of the zoecia.

In all the lateral walls there are pores at fairly regular intervals all over the walls, and besides there are in some cases disks with numerous pores near the opercular wall. Further, in a bilaminar piece of *M. armata*, there are in several cases large perforated disks on the basal walls, like those described in *Petralia* for the radicle attachment, though, strangely, in the unilaminar parts no distinct perforated disks have been found. This form cannot remain under *Membranipora*, though I am not suggesting that it is *Petralia*, but call attention to various similar characters in forms placed far asunder.

There are about 30 tentacles, which is a larger number than has been found in any true *Membranipora*. *Membranipora nigrans* Hincks and *M. marginella* H., with avicularia similarly placed near the distal end, have also curious large vicarious avicularia.

*Loc.* Port Denison, Holborn Island, 20 fath. (*Haswell*); Port Molle, Australia; Sagami Bay, Japan, 40 fath. (*Ortmann*). Wasin, Brit. East Africa, 10 fath. (500); Zanzibar Channel, from under-side of buoy (528), collected by Crossland.

#### MEMBRANIPORA CATENULARIA Jameson.

For synonyms see Miss Jelly's Catalogue.

Although the Arctic *M. monostachys* Busk from Franz Josef Land has many points of similarity, the operculum in *M. catenularia* from Zanzibar is only about half the width of that of the

\* Quart. Journ. Micr. Sc. vol. xxiii. p. 520 (1883).

† Arch. Slaves de Biol. vol. ii. p. 341 (1886).

‡ "Excretory Processes in Marine Polyzoa," Quart. Journ. Micr. Sc. p. 139 (1891).

§ "Cont. à l'hist. des Bryz." Arch. de Zool. Expér. et Gen. 2nd ser. vol. x. p. 581 (1892).

former species, and does not reach to the border of the opesium, so that they can be distinguished by this character.

*Loc.* Widely distributed, but there is much uncertainty about some of the determinations. Chuaka, Zanzibar, 3 fath. (506), 2 fath. (508), on the dorsal surface of *Steganoporella magnilabris* B., collected by Crossland.

*FARCINIA OCULATA* Busk. (Pl. LXVII. figs. 8, 9.)

For synonyms see:—

*Farcinia oculata* Waters, "Rep. on the Mar. Biol. of the Sudanese Red Sea, Bryozoa," Journ. Linn. Soc., Zool. vol. xxxi. p. 167 (1909); and add Canu, "Bry. des Terrains Tert. des Env. de Paris," Ann. de Paléont. vol. ii. p. 20, pl. ii. figs. 36, 37 (1907); "Bry. Helv. de l'Égypte," Mem. à l'Inst. Égyptien, vol. vi. p. 191, pl. x. figs. 16-19 (1912).

*Nellia tenella* Levinsen, Morph. & Syst. Studies of the Cheil. Bry. p. 120, pl. i. figs. 13 a-13 e (1909).

The growth is from a spreading stolon from which, at intervals, sub-colonies grow (figs. 8, 9), commencing with short calcareous nodes joined by chitinous tubes. There are usually three or four nodes in the stalk, though there may be only one. Quite similarly sub-colonies on a stalk with internodes grow from delicate stolons in *Chlidonia cordieri* Aud., *Diplodidymia complicata* Reuss (Pl. LXVII. figs. 11, 12), *Catenaria parasitica* Busk\*. I figured it some years ago for *Chlidonia cordieri* Aud.†, and since then Calvet and Levinsen have dealt with the species. All these species have a somewhat similar operculum, about the same size, and the number of tentacles in all is 11-12. They are probably more nearly related than we have imagined.

There are two very thick chitinous tubes connecting each new branch.

The ovarium, with several ovarian cells, often in a row, is near to the inner wall, about equidistant from the distal and proximal ends. One ovum grows extremely large, and is pressed into all kinds of shapes through want of room. The ovum passes into a sac near the basal wall and the distal end, and before an ovum has passed into it muscle-threads are seen radiating over this sac.

Levinson has figured the ovicell, which is a small cap-like growth, and this I have seen in a few cases, but often in zoecia with ovicelligerous zoecia no external difference is recognised. There is, however, often a vertical division separating the ovicellular wall from the rest of the zoecium.

The triangular mandible of the avicularium is found with difficulty and is extremely minute, being about 0.006 mm., while a large number of the mandibles, such, for example, as in *Retepora cellulosa*, are 35 times as long; some, as for example in *Lepralia*

\* The Honourable Mary Palk informs me that *Catenaria lafontii* Aud., grows on a similar stalk.

† Journ. Linn. Soc., Zool. vol. xxvi. pl. i. fig. 8 (1896).

*occlusa* B., are 60 times as long. In many cases there seems to be no mandible, only a disk, to which the peculiar body is attached, and this peculiar body is relatively very large. Smitt refers to the mandible of the Floridan specimens often being wanting, "presenting the opening closed only by a membrane."

There is no possibility of knowing what the *Cellaria tenella* of Lamarck was, and it certainly may have been *Cellaria*\*, so that, as I have previously said, it is better to retain the name *oculata*. The genus *Nellia* was not satisfactorily described, and therefore various authors have adopted the genus *Farcimia* of Pourtales and Smitt. Fleming had made a genus *Farcimia* which might include *Nellia*, but as he made it for *Cellaria*, with *C. fistulosa* as type, it was always a superfluous genus, and Smitt considered it non-existent. Although Levinsen adopts *Nellia*, it seems better to adhere to *Farcimia*, the name used in my recent papers, and which has been used by most workers recently.

*Loc.* See my paper referred to, and add Wasin, Brit. East Africa, 10 fath. (501); Prison Island, Zanzibar Channel, shore (503), 10 fath. (505); Ras Osowamembe, Zanzibar Channel, 10 fath. (504); Mweni Bay, Zanzibar, 6 fath. (510); Chuaka, Zanzibar, 3 fath. (526), collected by Crossland. Texas and St. Thomas, W. Indies (*Levinson*).

DIPLODIDYMIA COMPLICATA Reuss. (Pl. LXVII. figs. 11-15, & text-fig. 79.)

*Diplodidymia complicata* Reuss, "Foss. Fauna der Oligoc. von Gaas," Sitzungsber. d. k. Ak. der Wissensch. Wien, math.-nat. Cl. vol. lix. Abth. i. p. 469, pl. iii. figs. 6-9 (1869).

*Micropora ratoniensis* Waters, Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 185, pl. iv. fig. 5 (1887).

*Micropora articulata* Waters, Quart. Journ. Geol. Soc. vol. xlvii. p. 14, pl. ii. figs. 5, 6 (1891).

From Chuaka, Zanzibar, there are several pieces throwing light on this form, which has only been seen in fragments previously.

The zoarium has a stalk consisting of long barren internodes, sometimes as many as eight, followed by long articulated internodes with the zoecia placed diagonally on the four sides. The contents of the barren internodes send out a branch to the surface, just as we have seen in *Chlidonia cordieri* Aud. From near the starting-point of each sub-colony a number of narrow radicles radiate, and sometimes from one of these radicles a fresh sub-colony grows, as is frequently the case in species with creeping stolons.

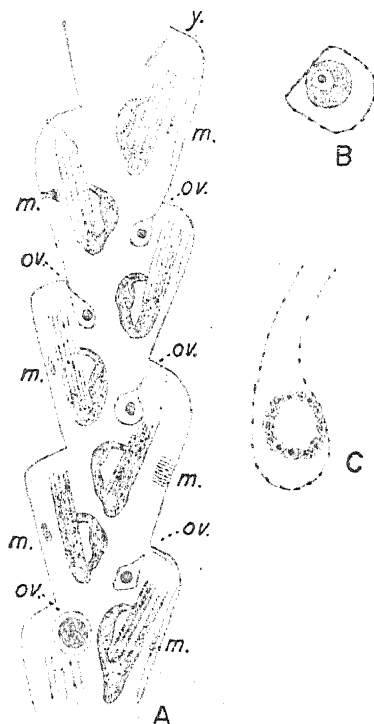
The branches are dichotomous and articulated, having two chitinous tubes forming each articulation. Occasionally there are more than the four rows, but this will only be for a short distance near the articulation, and in one piece there is a median

\* Busk gives it with ?synonym of *Cellaria gracilis* Busk.



line on the dorsal surface with the zoœcia on each side. The front wall has a minute pore on each side below the oral aperture (fig. 13), but these are only seen in Eau de Javelle preparations, and in the same way the long slit-like pore on the one side is scarcely seen so long as the membrane covers the walls. The muscles passing through this slit are wide, and are attached to a

Text-fig. 79.

*Diplodidymia complicata* Reuss.

- A. Showing small sacs hanging from the opercular region, and in each an ovum grows (ov.). At *y.* there seems as yet no ovum in the small sac; *m.*, the muscles of the operium.  $\times 50$ .
- B. Section showing an ovum in the small sac.  $\times 250$ .
- C. Section in which the ovum has segmented and a blastula is formed.  $\times 250$ .

chitinous thickening or sclerite on the front membrane, and are partly protected by a calcareous wall. There are two rosette-plates in the entire lateral wall. On the avicularian chamber there is a concave pit with a central perforation, no doubt indicating that radicles can be given off from this pit, and thereby

the two pores described in the fossil *Micropora articulata* Waters are explained, the one being the avicularian and the other the radicular opening. The avicularium is by the side of the aperture, and the mandible is triangular.

There are 11-12 tentacles.

The testes extend all down the lateral wall. A very few small ovaria with one to three small ovarian cells were found.

A small ovum is found in a small sac hanging from the opercular region (text-fig. 79). The sac and ovum grow until ultimately the embryo nearly fills the zoecium, and now there are small muscles from the opercular wall to the ovicell and a strong lateral band. There is no external indication of any ovicell nor of which cells contain an embryo. The embryo is relatively large, with the couronne very large and distinct, and the way in which the embryo grows in the pendant sac may throw light upon the development of the ovum and embryo in *Adeonella*, but no stage has been found with a sac hanging from the opercular region in *Adeonella*.

The present species, as I have previously indicated, is closely allied to the fossil *Cellularia diplodidymoides* Meun. & Pergens from the Chalk, and both belong to the same genus\*. Canu has described four fossil species from the Paris Basin, but, unfortunately, he has not given figures as well as photographs. In the work there are a number of magnificent photographs, showing the characters most beautifully, but some of the Paris authorities are making too hard and fast a line that everything must be photographed. The specimens in question (pl. v. figs. 6-10) do not lend themselves to photography, and require either figures or full description for elucidation.

These Zanzibar specimens are so different in the younger and older joints that with fossils several species might be made from one colony.

Canu† says that the genus *Diplodidymia* is the *Poricellaria* of d'Orbigny, but the description of this latter leaves recognition impossible without direct comparison, and therefore Canu is quite right in retaining the name *Diplodidymia* Reuss.

*Loc.* Off Katow, New Guinea, 7 fath.; Singapore (fide *Whitelegge*, in lit.). Chuaka, Zanzibar, 3 fath. (506), collected by Crossland.

*Fossil.* Gass, near Dax, S. France, Oligocene; Montecchio Maggiore, N. Italy, Bartonian.

*CHLIDONIA CORDIERI* Audouin. (Pl. LXV. figs. 15, 16.)

*Eucratea cordieri* Aud. Descrip. de l'Égypte, Hist. nat. p. 242, 2nd ed. p. 74; Savigny's pl. xiii. fig. 3.

*Chlidonia cordieri* Waters, Journ. Linn. Soc., Zool. vol. xxvi.

\* "Bryozoaires du Système Montien," Louvain, p. 3, pl. ii. fig. 3 (1886).

† "Bryozoaires des Terrains Tertiaires des Environs de Paris," Ann. de Paléont. t. ii.-v. p. 39 (1907).

p. 18, pl. i. figs. 8, 9 (1896), which see for synonyms, and add: Calvet, "Bry. Mar. de Cete," Trav. de l'Inst. de Zool. de l'Univ. de Montpellier, ser. 2, mem. 11, p. 13, pl. i. figs. 1, 2 (1902); "Bry. Mar. des Côtes de Corse," op. cit. mem. 12, p. 6 (1902); Levensen, Morph. & Syst. Studies on the Cheil. Bry. p. 197, pl. viii. figs. 6 a-6 y (1909).

From the front wall to the zoecial wall, through what has been called a second chamber, but is the equivalent of a compensation sac, there is a bundle of three, four, or more muscles (see fig. 15). The attachment of these on the front has been mistaken for a suboral pore, and in dried specimens there is frequently an opening here.

No ova or ovaria have been found in any of my sections, whereas some show an embryo about half filling the zoecium, though no external difference has been noticed.

The operculum is interesting, as it has at each side a projection or wing at right angles to the operculum (figs. 15, 16); also at each distal corner there is a slight projection. The wing reminds us somewhat of the thin membranous growth of many Membranipora and some Micropora.

There are 9-11 tentacles.

Loc. Red Sea (*Aud.*); Naples, Trieste, Rapallo, Nice, Cete, Corsica, Algiers, Tunis, Tyre, Calvados, Egypt, Victoria (Australia), Cape York, New Zealand, Atlantic (fide *Carus*); Canaries (*d'Orb.*). Wasin, Brit. East Africa, 10 fath. (500), on calcareous seaweed, collected by Crossland.

#### CELLARIA.

Levensen, following Norman, uses *Cellularia* for what we understand as *Cellaria*, but as these names have long been used for widely distinct genera I must certainly, in the most definite manner, refuse to use the name *Cellularia* for what we have for many years understood as *Cellaria*.

*Cellularia* of Pallas was a simply ridiculous jumble of forms for which a place had not been found elsewhere. The species mentioned by him are now placed in nine genera, one of which is the Cyclostome *Crisia*, and as the description of the genus refers to the ovicell of *Crisia*, perhaps the least objectionable thing would have been to have retained the name *Cellularia* for *Crisia*. The real difficulty, however, is that the name *Cellularia* has been retained for a quite different group, and to interchange and now use a name long understood in a different sense would cause the greatest confusion.

Solander employed the name *Cellaria* for a group approximately, but not absolutely, similar to the *Cellularia* of Pallas, giving a definition also not quite the same, and it has been considered to be only a change of spelling, though curiously, Ellis & Solander never indicate that they considered it was the same as *Cellularia* of Pallas, nor throughout the description of the genus

do they ever refer to Pallas, although many of the species dealt with had been mentioned by that author. This is certainly difficult to understand, and perhaps would have been different if Solander had lived to complete the work himself.

Hincks considered that the species in Solander's genus had all found places elsewhere, and that the genus of Solander had lapsed. He therefore took *Cellaria* as the genus of Lamouroux, who under *Cellaria* put *Cellaria* (as now understood) with the type *C. salicornia* and also *Tubucellaria*. Lamouroux says of all genera none seems to contain as widely distinct species as this, and that it seems to have been formed to contain everything that could not be placed under *Flustra* or *Sertularia*.

Instead of dropping *Cellularia* as hopeless, Busk unfortunately retained it for a small division, and this has been accepted.

The first species mentioned by Pallas in his genus is *tubucellaria*, which also is included in Lamouroux's *Cellaria*, though not as the type, which was *Cellaria salicornia*; and Stoliczka\*, in a long discussion of the subject, took the view that as *tubucellaria* was first mentioned the genus must be called *Cellaria*, and *Cellaria*, as now understood, must be separated as *Salicornia*.

We now see that it is unfortunate that Hincks should have retained *Cellaria*, though it then appeared that this would not be challenged, and it has been adopted generally, and no genus seemed more firmly established. However, it is now clear that if Hincks had continued to use *Salicornaria* there would have been no possibility of the name of a now long recognised genus being replaced by one used in most various ways, and now limited to another small group.

Those who are at work upon the class know how often the descriptions of the earlier authors are now meaningless, for the characters then used are found to be useless; but this can hardly be appreciated by those who have not had occasion to consult such descriptions. It is as if some well known tree had generations ago received a name and a few lines of description which would apply to a quarter of our phanerogams and some cryptogams.

I have previously shown that we are brought into a perfectly ridiculous position by being asked to adopt such names at all costs, when we often have no idea what they meant. It is not science, and since *Cellaria* as modified by Hincks is well established I shall still use it †.

\* Foss. Bry. aus dem tert. Grünsand. der Orakei Bay bei Auckland, pp. 142-149 (1864).

† Norman ("Polyzoa of Madeira," Journ. Linn. Soc., Zool. vol. xxx. p. 293 (1909)) challenges the correctness of considering that *Tubucellaria opuntoides* should have been considered the type of *Cellularia*, but I cannot agree with his conclusions as to what I say being contrary to the British Association Rules of Nomenclature. My edition is later than Norman's, but apparently is only a reprint, and it says "When they omit doing so" (i. e. fixing a type), "it may still in many cases be correctly inferred that the first species mentioned on their list, if found accurately to agree with their definition, was regarded by them as the type." This rule of course means that if the generic diagnosis is taken from some one species, and that an error has been made in including the first, then common sense may be

CELLARIA GRACILIS, var. TESSELLATA, nov. (Pl. LXVII. fig. 7.)

For synonyms of *Cellaria gracilis* see Miss Jelly's Catalogue and add:—

Meissner, "Liste der von Herren Prof. Simon bei Amboina und Thursday Island ges. Bry.," Jena Denkschr. vol. viii. p. 730.

A specimen from Ras Osowamembe growing on Hydrozoa seems to be a variety of *C. gracilis*. In this specimen the trabeculae mentioned by Busk enclose an area formed of large tessellated divisions, about 20 (fig. 7); and curiously, another species, which I call *C. wasinensis*, sp. n., has also a tessellated area, but the avicularium of that species is triangular with an acute mandible, and belongs to the *C. tenuirostris* group. These large tessellated areas are unusual, and have not been found in various species of *Cellaria* in my collection; nor in the British Museum 'Challenger' collections are they found in *C. bicornis* B., *C. dubia* B., *C. malvinensis* B., *C. variabilis* B., *C. divaricata* B., *C. australis* Hincks, *C. rigida* MacG. The significance both of the trabeculae and of the divisions is at present obscure.

The opercula are a trifle larger than the type from Holborn Island, but the mandibles are the same.

*Loc.* Type: Cumberland Island; Cape Capricorn; Victoria, 8 fath.; Torres Straits; Holborn Island (Queensland); Katow, New Guinea, 7 fath. Variety: Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

CELLARIA WASINENSIS, sp. n. (Pl. LXVII. figs. 1-6.)

Zoarium about 25 mm. high, with small branches dichotomously jointed and connected by two or three stout straight chitinous tubes and a "knot." The zoarium swells out where the ovicells occur, as is frequently the case in *Cellaria*, there being sometimes two such swellings in an internode; and it will be seen on fig. 6 how these are equidistant from the joint in the two branches.

The zoecia are rather elongate, hexagonal, or rhombic, with the lateral walls of the zoecium much raised, surface finely granular; oral orifice wide, with two teeth on the distal edge, which is slightly turned up, forming a lip.

The ovicellular aperture is large, round, with a plate from the proximal border spreading out and partially closing the aperture.

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used in saying the first is not the type, but surely it never meant that any individual could subsequently pick and choose which was the type among those agreeing equally well. However, in my work, to which Norman refers, I and other specialists were under an obligation to follow the rules of the Zoological Congress, and the rule in question is "other things being equal the name is to be preferred which stands first in the book or article." In anything I write now the same obligation does not exist, though the rule entirely commends itself, and it does not seem to clash with the rules previously mentioned, drawn up by Strickland. Both practically say that when there are adequate reasons to indicate which was the type intended, that may be considered the type although not first mentioned, but without good cause to the contrary the first is the type, and independently this is what workers are constantly doing.

The ovicellular opening of *C. gracilis* Busk, var., *C. australis* MacG., *C. rigida* MacG., and *C. hirsuta* MacG., is similar; but in the few cases where the ovicellular aperture is mentioned, it is often only the incompleated opening in an early stage which is described.

The avicularia are triangular with mandibles like those of *C. tenuirostris* B. In the avicularium the calcareous submandibular wall rises up to the proximal edge of the mandible with a notch on each side, perhaps for the muscles (fig. 5), so that the submandibular part of the avicularium is almost entirely closed; and this is an interesting point, for Levinsen considers that the Meliceritidae differ from the living Cheilostomata in having the submandibular portion entirely calcified.

As I have mentioned\*, there is, however, a specimen in the Museum d'histoire naturelle in Paris from the Bancs des Aiguilles, S. Africa, which is probably the *Macropora cribrilifera* Maplestone†, fossil from Mitchell River, in which the large vicarious avicularia have the submandibular part entirely calcified. Maplestone mentions that three of the zoecia have a "calcareous closure." I have previously stated that there seem to me to be some points of relationship between *Cellaria* and Meliceritidae.

Levinson deals but very shortly with the avicularia of *Cellaria*, and I am not quite sure that I follow what he means about the avicularium of *C. malvinensis*. He, however, says that the submandibular cryptocyst reaches up to the operculum in *C. fistulosa*. I have not seen it rise as it does in *C. wasinensis* in any of my specimens of *C. fistulosa* L., but there is a similar wall rising to the base of the mandible in *C. variabilis* B., *C. hirsuta* MacG., and *C. gracilis* B.; *C. variabilis* has two slits in the submandibular part. More frequently there is an open rounded submandibular space as in *C. dennanti* MacG.‡, *C. malvinensis* B.‡, *C. australis* H., *C. fistulosa*, *C. tenuirostris* Busk, and *C. waudeli* Calvet. In *C. fistulosa* this is not much more than a wide round sinus.

There are two species which have been taken for *C. malvinensis* B. The first, which I have from Wanganui, New Zealand, has a fairly large submandibular space with a distinct ridge where the proximal end of the mandible comes, in fact in a few cases this is continued, forming a bridge across. The mandible soon contracts, with the distal end lanceolate. The other form is slightly smaller, from Baie Orange, S. Africa, and mentioned by Jullien as *C. malvinensis*. It has the sides of the zoecia straight, the distal end rounded, and the submandibular part of the avicularium rises up to the mandible, having two diagonal slits. The mandible is shorter than in the other species, sloping gradually to the apex. Whenever this is figured it might be called *C. jullieni*. The

\* Résultats du Voyage du S.Y. Belgica, "Bryozoa," p. 35 (1904).

† "Further Desc. of the Tert. Poly. of Victoria," Proc. Roy. Soc. Vict. vol. xiii. n. s., p. 204, pl. xxiv. fig. 2 (1901).

‡ Rés. du Voy. du S.Y. Belgica, pl. ii. fig. 9a & pl. viii. figs. 4, 5.

forms from Curdies Creek which I considered to be *malvinensis* have since been separated by MacGillivray as *C. contigua*, but the fossils from Bairnsdale and New Zealand are *C. malvinensis*.

The operculum of *C. wasinensis* is nearly semicircular with large hollows fitting on to the teeth, and is similar to the operculum of *C. gracilis*. The trabeculae (figs. 3, 4) enclose in the lower part large divisions, about 7 in number, and the divisional walls are very thick, whereas in *C. gracilis* var. *tessellata*, nov. (fig. 7), they are linear with numerous divisions.

There are about 13 tentacles. In *Cellaria* we find \* the number of tentacles is approximately the same throughout the genus, only *C. dennanti* MacG., a species showing other differences, has 20. Now *Cellaria* is a well marked genus having opercula of a special form, with a hollow cup fitting on to the teeth in the oral aperture, and the ovicell has a characteristic chamber, and also a characteristic ovicellular aperture.

Levinson † states that a zoecium does not correspond with an area, but with this I cannot agree, as I find the superficial divisions approximately mark off the zoecia, even though they may in parts extend somewhat under the divisional line, and this is the case in many genera.

The ovarium usually has two ova, though there may be one or three, and the ovum is large when it enters the ovicell.

*Loc.* Wasin, Brit. East Africa (501) (507), 10 fath.; Ras Osowamembe, 10 fath. (504); Prison Island, Zanzibar Channel (505), 8 fath.

*Cellaria tenuirostris* B., *C. salicornioides* Aud., *C. magnifica* B., *C. malvinensis* B., *C. gracilis* B., have been previously described from tropical regions.

#### THAIROPORA MAMILLARIS Lamouroux.

*Flustra mamillaris* Lamouroux, "Polyp. corall. flexibles," p. 110 (1816) and add to Miss Jelly's synonyms:—

*Thairopora mamillaris* MacG. Prod. Zool. Vict. dec. xx. p. 351, pl. 196, fig. 2 (1890).

*Membranipora mamillaris* Hincks, Ann. Mag. Nat. Hist. ser. 6, vol. viii. p. 91 (1891).

*Thalamoporella mamillaris* Levinson, Morph. & Syst. Studies on Cheil. Bry. p. 194, pl. vi a. figs. 5 a-5 e (1909).

There is a small piece from Chuaka, Zanzibar, which was decalcified when received. It was preserved in HgCl<sub>2</sub>, but no doubt there was acid as well. The main points could, however, be seen, and the opercula and mandibles were separated, and although the mandibles are smaller than in the specimen received from the Red Sea, to which reference is made below, yet they are quite characteristic of *T. mamillaris*. Levinson has shown that there are calcareous spicules in all the Thalamoporellidæ, affording

\* Résultats du Voyage du S.Y. Belgica, "Bryozoa," p. 37 (1904).

† Morph. & Syst. Studies on the Cheil. Bryozoa, p. 211.

good specific characters, and the way in which he has dealt with them is one of the most important features of his book.

*Loc.* Victoria (*MacG.*); South Australia (*my coll.*); a weed, brought up on the sounding-line in the Red Sea, covered with this species, was given to me by a passenger. We may take it that there is every probability of its being from the Red Sea, though we cannot record it as such without pointing out the possibility of its having remained on the line from some previous locality. Chuaka Bay, Zanzibar, 2 fath. (509), collected by Crossland.

STEGANOPORELLA MAGNILABRIS Busk. (Pl. LXXII. figs. 12-20.)

*Membranipora magnilabris* Busk, Brit. Mus. Cat. Mar. Polyzoa, p. 62, pl. lxxv. fig. 4, in the explanation of the plate called *M. grandis*.

*Steganoporella magnilabris* Harmer, "Rev. of Gen. *Steganoporella*," Quart. Journ. Micr. Sci. vol. xliii. p. 279, pl. xii. fig. 10, pl. xiii. figs. 31, 44-46, which see for synonyms. Add Thornely, "Mar. Poly. of the Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 145.

Specimens from Wasin agree in most respects with the description of this species, though the mandibles of the A zoecia having no teeth are more like those of *S. buskii* Harm. However, a comparison with the British Museum specimens has led to my leaving them under *magnilabris*, though some workers might\* separate them as a variety. The zoecia are bilaminar, irregularly contorted, and evidently attain to a very considerable size, as some pieces, evidently only fragments of larger ones, measure two or three inches across.

There are very few B zoecia, in fact two mounts, each containing about 300 zoecia, had no B zoecia. On examining all the remaining material a few scattered B zoecia were found, and it is interesting to find that from these zoecia, which are somewhat larger than most A zoecia, two new zoecia usually arise, that is the row here bifurcates, and to this but few exceptions were found in all the material examined.

I called attention to this duplication from the B zoecia occurring in some fossils, but Harmer† has shown that it is by no means universally the case. At the time I wrote very little material was available for comparative study. It, however, is a fact that in many species two zoecia usually, or at any rate frequently, grow from the distal end of B the zoecia. In this species, when the operculum is removed, it is often not possible to be sure which are B zoecia, as there are large A zoecia, with a large shelf, in all respects similar excepting the operculum, so that with fossils there will often be uncertainty. In most other species there is a greater difference between the A and B zoecia. The A opercula vary considerably in size. In a specimen from (508) the B zoecia are much more common than in those from (500).

\* "Bryozoa from Aldinga," Quart. Journ. Geol. Soc. vol. xli. p. 292.

† Revision of the genus *Steganoporella*, p. 266.



According to Harmer the A zoecia are in most species of *Steganoporella* more abundant than the B, and he says there are no B in *S. simplex* H., and goes on to say that they are rare in *S. sulcata* H., *S. lateralis* H., and *S. magnilabris* B. In *S. truncata* H. the ratio of A to B is 4-5 to 1; on the other hand, in *S. alveolata* H., there are few A zoecia, and *S. connexa* H. has only B zoecia.

As Harmer\* has shown, there is considerable difference in the teeth of A opercula of *magnilabris* from various localities, and we have opercula of this Wasin specimen without any, also the B opercula may be with or without lateral teeth. The A opercula of a 'Challenger' specimen (208.90.4.16.13) has the teeth so minute that they would be overlooked with a low power, but are seen with a quarter-inch objective.

The operculum of *Steganoporella* can scarcely be compared with the opercula of other Bryozoa, as it closes the whole of the distal chamber, and in a zoarium there is an amount of variation in size of the opercula which is unknown in other genera of Bryozoa. In a British Museum specimen of *S. truncata* Harm. from Port Dalrymple, there are a few cases where the operculum is thrown back, and then the whole of the opercular opening (that is over the distal chamber) is covered by a membrane with a large round opening, thus furnishing a most interesting form of closure.

The wall, dividing the two chambers, passes vertically from the opercular wall to the basal wall, and in the middle there is a round opening, sometimes with a slight tubular projection through which the polypide passes. The polypide rests partly in the two chambers, that is the tentacles are not entirely withdrawn into the proximal chamber. The embryos develop at the base of the distal chamber, but this chamber can by no means be spoken of as an ovicell.

The Wasin specimens show some blind zoecia either entirely closed or with a central opening, and the same occurs in a specimen of *S. tubulosa* H., where two zoecia are about the normal size, one with a large round opening, the other with an oval one, and in these the whole of the frontal wall is granular. On the other hand, a British Museum specimen of *S. sulcata* H. has two zoecia entirely closed by the perforated cryptocyst.

The *S. magnilabris* from Wasin has floating in the proximal chamber many small oval bodies, surrounded by a membrane containing diatoms and other detritus. These are the excrement pellets, and they are evidently frequently ejected within the zoecium.

Study of the growing ends is instructive. At first there is an absolutely empty oblong zoecium covered with a plain membrane, and in this either A or B opercula may be formed, but at first the operculum has no basal sclerite (fig. 20), as this is formed subsequently. Next the proximal part of the cryptocyst

\* *Loc. cit.* p. 234.

is formed (fig. 20,  $z\ 2-z\ 3$ ), then the tube or opening between the two chambers (fig. 20,  $z\ 4$ ) which is at a much lower level than the operculum, next the lip is formed, which at last reaches up to the operculum. The muscles are formed after the operculum, and the polypide not until after the tube and lip.

It has not been mentioned that the part between the main sclerite of the operculum is covered by a membrane, thus enclosing a space (fig. 17), and the tentacular sheath is fastened\* between the two muscular attachments of the operculum, having a tissue across from one muscular attachment to the other (fig. 19, from  $r-r'$ ). As mentioned, the large distal muscle is attached to the operculum, but the large muscle just proximal to it in the A zoecia is fastened by a tendon to the frontal membrane (fig. 19 *d*) close up to the operculum, where there is a slight thickening or sclerite. Harmer† speaks of this muscle as perhaps inserted into the frontal membrane immediately adjacent to the basal sclerite.

Further back (proximally) there is on each side a diagonal sclerite (fig. 14, *sc.*), to which the tendons of a smaller muscle are attached, which draws down the frontal membrane‡. These are called depressor muscles by Harmer§||.

In the B zoecia the retractor muscles are much larger than in A, and are in two groups instead of one, but in the present species I am unable to find any very material difference between A and B zoecia.

The embryos develop at the base of the distal chamber, but this chamber cannot be spoken of as an ovicell, for the polypides are, even when retracted, partly in this chamber. It seems that the embryo may exceptionally be in the proximal part of the zoecium surrounded by a membrane, really an internal ovicell. This requires investigation.

The first polypide buds in the growing terminations are in the proximal end of the young zoecia as usual, and are nearly always in one of the corners, consequently the polypide grows diagonally across the zoecium, causing a slight amount of asymmetry in the zoecium. The buds of the Bryozoa usually grow from near to a rosette-plate, the position of bud and polypide being thus affected by the position and number of these plates. In *S. magnilabris*, and probably generally in the genus, there are two large distal rosette-plates. In decalcified preparations a curious large fleshy

\* We must keep in mind that in the Cheilostomata the tentacular sheath is fastened to the operculum and to the zoecial wall.

† "Morph. of the Cheilostomata," Quart. Journ. Micr. Sc. n. s., vol. xlv. p. 318 (1902).

‡ This was not readily made out at first, but some thick sections stained in Chlorazol blue enabled me to see it all clearly. This is a stain that will be found useful for staining muscles and some other tissue, but it is not a good nuclear stain. Material can be stained and decalcified at the same time, as acid does not affect the colour and it may be used for *intra vitam* staining. This stain was given to me by my friend Mr. Waddington, who has been unable to find out particulars as to its constitution.

§ *Loc. cit.* p. 320.

|| It is interesting to find that the large "pores" in the cryptocyst of *Cupularia oweni* Busk are only for the passage of depressor muscles.

structure is found in connection with them (fig. 16). On the inner side (towards the older zoecium) there is a large saucer-like portion with a fleshy club-like projection on the other. The wall of the zoecium and the rosette-plate passes between the two.

From the tissue round one of these rosette-plates the polypides of the growing parts start, but many of the polypides have the retractor muscles always attached to the lateral wall. The tentacular part of the bud seems to be growing in one distal corner while the gut parts are growing in the other, and in the mature polypide a long tube connects the two (fig. 12). This narrow tube connecting the two parts is a character of the mature polypide, and is somewhat like that of the œsophageal tube of the Ctenostomata.

There are very few secondary buds to be seen (as the zoecia nearly all contain perfect polypides); they, however, arise from tissue on the membrane crossing the operculum.

There are about 25 tentacles, four of which near the base are larger and broader than the others.

In other species of *Steganoporella* there is also considerable variation in the teeth of the opercula; for example, in a specimen of *S. buskii* H. from Algoa Bay, South Africa, in the British Museum, there is a B operculum without any teeth whatever, whereas the other opercula have small teeth.

*Steganoporella* is not yet known before late Tertiary, whereas *Thalamoporella* is much older.

*Loc.* Brazil; Jamaica; St. Vincent; Florida; China Seas; Singapore; Philippine Islands; Trincomalee; Amirante Isl., 20-25 fath. (*Thornely*). Wasin, Brit. East Africa, 10 fath. (500) (520); Chuaka, Zanzibar Channel, 2 fath. (508), collected by Crossland.

*Fossil.* Australian Tertiaries.

#### CRIBRILINA RADIATA Moll.

*Loc.* Cosmopolitan. Ras Osowamembe, Zanzibar Channel, 10 fath., on *Adeonella platalea*, collected by Crossland.

#### HIPPOTHOA DIVARICATA Lamouroux.

*Loc.* Wasin, Brit. East Africa, 10 fath. (520), on shell, collected by Crossland.

#### HIPPOTHOA DISTANS MacGillivray.

For synonyms see Waters, "Bryozoa," *Résultats du Voyage du S. Y. Belgica*, p. 54 & pl. iii. fig. 8 (1904).

*Loc.* Wasin, Brit. East Africa, 10 fath. (520), on shell, collected by Crossland.

#### SCHIZOPORELLA UNICORNIS Johnston.

Waters, "Bryozoa of the Sudanese Red Sea," *Journ. Linn. Soc., Zool.* vol. xxxi. p. 143, pl. xii. figs. 12, 13 (1909).

Some pieces are either one or two layered, and here again I

have been able to see the zoecia superimposed, so that both lateral and distal walls of the upper layer are above the similar walls of the lower layer\*. Reuss has shown the same thing in *Cumulipora angulata* v. M., and I have in previous papers referred to it in Melicerititidae.

In some other species of *Schizoporella* the superimposed layers grow quite differently (see p. 504).

*Loc. Add*: "From bottom of s.s. 'Juba,' which always remains in Zanzibar waters" (511), collected by Crossland.

#### SCHIZOPORELLA PERTUSA Esper.

See Miss Jelly's Catalogue, and add:—

*Lepralia pertusa* Calvet, "Bry. Mar. de Cette," Trav. Inst. de Zool. de l'Université de Montpellier, ser. 2, vol. i. p. 51; "Bry. Mar. de Corse," op. cit. vol. ii. p. 26; Jullien & Calvet, "Bry. prov. des Camp. de l'Hirondelle," pp. 69, 134.

*Schizoporella pertusa* Calvet, "Exp. Sc. du Travailleur et du Talisman," p. 416.

*Loc.* British; Labrador; Atlantic; Florida; Mediterranean; Mazatlan; Australia; Samoa; China Seas. Wasin, Brit. East Africa, 10 fath. (500) (520), collected by Crossland.

SCHIZOPORELLA NIVEA Busk. (Pl. LXX. figs. 1-3, 7-9, & Pl. LXXIII. fig. 16; and text-fig. 80.)

*Schizoporella nivea* Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 163, pl. xvii. fig. 1 (1884); Philipps, in Willey's Zool. Results, pt. iv. p. 440 (1889); Thornely, Ceylon Pearl-Oyster Fisheries, vol. iv. p. 114 (1905); Rec. Indian Mus. vol. i. pt. 3, no. 13, p. 189 (1907); Waters, Rep. Mar. Biol. of the Sudanese Red Sea, "Bryozoa," Journ. Linn. Soc., Zool. vol. xxxi. p. 168, pl. xvii. figs. 2-4 (1909); Thornely, "Mar. Poly. of the Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 148 (1912).

Zoarium in Hemescharan form. Zoecia quadrate, distinctly separated, fairly large pores over the surface, an avicularium near each upper corner with broad triangular to nearly semi-circular mandibles, sometimes a small avicularium at one of the lower corners. Below the aperture there is frequently, in the older zoecia from (501), a mucro which may be long spreading out at the ends, or there may be a thin lamina radiating in four directions the whole length of the mucro. These mucros are more frequent on the ovicelligerous zoecia. The oral aperture is nearly circular, has a wide poster, and there are fine lines across the operculum (fig. 2).

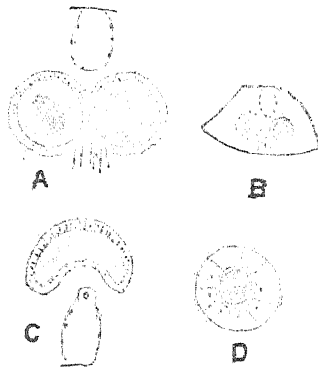
The ovicell is large, raised, globular, with a ridge from the middle of the proximal edge, shortly bifurcating to each side, at any rate in the older zoecia. The pores over the surface of the

\* Reuss, "Zur Fauna des deutschen Oberoligocäns," pt. ii., Sitzb. d. k. Akad. der Wissensch., Wien, math.-nat. Cl., vol. l. Abth. 1, p. 644 (31), pl. ix. fig. 1 (1864); "Die Foram., Anth. und Bryozoen des deutschen Septarienthones," Denk. s. d. k. Akad. der Wissensch., Wien, math.-nat. Cl., vol. xxv. p. 179 (63), pl. viii. fig. 12 (1865).

ovicell are fairly large, though slightly smaller than those of the zoëcia.

The small avicularium at the distal corner (figs. 7-9) has short and wide glands which at the lower part are joined together, and no other avicularian glands yet seen quite resemble these (text-fig. 80). Avicularian glands occur in *Lepralia foliacea* Ell. & Sol., *L. clirosa* Waters, *L. margaritifera*, *Smittia trispinosa* Johnst., *Porella plana* Hincks, *P. acutirostris* Smitt, *Retepora cellulosa* L., and other *Retepora*. In all these cases there are also oral glands. The oral glands of *S. nivea* are but small with the end cells the larger and darker (Pl. LXXIII. fig. 16, *gl.*).

Text-fig. 80.



Avicularian glands of the small avicularia of *Schizoporella nivea*.

A, the two glands separated,  $\times 320$ . B, the same,  $\times 100$ .  
C, glands united,  $\times 320$ . D, gland,  $\times 320$ .

There are 16 tentacles, no pore-chambers, but on the lateral walls there are about eight rosette-plates near the basal wall, also on the distal wall there are about six situated near the base.

The internal membrane of the zoëcium projects in a sac-like manner into the ovicell (fig. 16). This sac is about the width of the zoëcium, and is provided with a large number of muscles (fig. 16, *sc.*) radiating from near the operculum. From a whole preparation it seems that the ovum passes into this sac, which is then ruptured (fig. 16, *r*) to allow of the passage of the large ovum into the ovicell. I think there is no doubt of my interpretation, although a ruptured membrane has only been seen in one case. The ovary consists of a number of large ovarian cells.

Some of the older zoëcia are closed by a calcareous layer over the operculum, with a calcareous bar or lamina, extending from side to side (Pl. LXX. fig. 3) curving round to the sinus, a position which is fairly constant, not accidental. In older zoëcia there is sometimes a calcareous bar straight across the aperture, and there

may be no operculum remaining underneath it. Frequently a tubular projection occurs in the middle of the supra-opercular calcareous layer, and there is a closure of the same kind in *Schizoporella unicornis* and other Schizoporellidæ and various other genera besides some Tertiary fossils; and a similar structure has been described in "*Lepralia*"\* *syringopora* Rss. and is found in various Adeonidæ†. It can be seen in *S. nivea* that these raised ledges across the operculum are the basal lines for a superimposed layer even though the layer is seldom completed; and a South African species which, though a larger and distinct form, is very similar to *S. nivea*, explains the growth across the operculum more fully. In it we have the commencement of a superimposed new layer of zoëcia, and in one specimen there are about fifty zoëcia together on which the walls for another layer are all mapped out, and the wall passes over the operculum, nearly always with the same curved line as in *S. nivea*.

I described and figured a similar growth in *Meliceritites*‡ and apparently it occurs in various other cases. On the other hand, I have specimens of *Schizoporella unicornis* Johnst. from Cape Verde Islands and Zanzibar, in which there are many layers, and each following layer is formed by the new walls, nearly always growing exactly above the walls of the older layer. Nevertheless, there is, in some cases, a curved calcareous ridge over the operculum for which there seems no object. In *S. unicornis* there is often a tubule on the calcareous closure.

Some stained sections of *Adeonella contorta* Mich. in which there are superimposed layers, show this tubule as an inverted funnel with a long tube (over the operculum) attached to the tissues below the operculum. These closures can only be compared, in a limited sense, with the tubules of the closures of the Cyclostomata, as the operculum is unaltered and there is no perforation. There are also membranous closures, and the subject deserves further study. The Schizoporellidæ and the Adeonidæ are apparently the two families most likely to throw light on the closures of the Cheilostomata. Of course we do not find the closures in the younger zoëcia, only in the older ones. In both these families blind cells are very frequent§.

The Zanzibar forms are not separated as varieties or species, although the one with the tall mucro might perhaps be called var. *wasinensis* (Pl. LXX. fig. 1) on this account. It may be the *Schizoporella linearis* of Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. vii. p. 159, pl. ix, fig. 2, to which there is no description or locality.

\* Waters, "North Italian Bryozoa," Q. Journ. Geol. Soc. vol. xlvii. p. 20, pl. iii. figs. 3, 4 (1891).

† Waters, "A Structure in *Adeonella contorta* Mich.," Ann. Mag. Nat. Hist. ser. 8, vol. ix. p. 498 (1912).

‡ "On Cheilostomatous characters in fossil Bryozoa," Ann. Mag. Nat. Hist. ser. 6, vol. viii. p. 52, pl. vi. fig. 4 (1891).

§ Since the above was written Levinsen has published an important work, "Studies on the Cyclostomata Operculata," D. Kgl. Danske Vidensk. Selsk. Skr. 7 R., Nat. og Math. Afd. vol. x. pt. 1, 1912, dealing with Meliceritidæ.

What he calls the opercula of these fossils I should speak of as the closures, for

Frequently a hydroid is growing over the surface. This seems to be a species of *Clava* and may be the same species as one growing in *Holoporella columnaris* B., and *H. pigmentaria* Waters, in which it may pass through several layers of zoecia. Sections showed that the stolons were spread under the *H. columnaris*, indicating that the growth of the *Holoporella* occurred over established colonies of *Clava* round which the *Holoporella* formed calcareous tubular walls \*.

(1) *S. nivea* belongs to a group in which all the species have a wide sinus or arc, the surface is perforated as is also the ovicell, there are quite small oral glands or but very moderate sized ones. The opercula have the muscular attachment close to the border and fairly near to the distal end. This group I referred to † as including the types of *Schizoporella*, and belonging to it are *S. sanguinea* Norm., *S. linearis* Hass., *S. harmsworthii* Waters, *S. auriculata* Hass., *S. galeata* B.? etc., and a new species from S. Africa. Levinsen includes several other species under *Schizoporella*, but I am by no means sure that all his species will remain in the same genus, for in (2) *S. unicornis* Johnst. and var. *errata* Waters, *S. longirostris* Hincks, *S. spongitis*, *S. biaperta* Mich., the sinus is much narrower, and what is of most importance, the muscular attachments are some distance from the border of the operculum. In *S. biaperta* the ovicell has a flat area with perforations round the border.

(3) In the group *S. vulgaris* Moll., *S. viridis* Thorn., there is a similar operculum, and it is in part the *Escharina* of Levinsen.

In the same place I showed that there was a group which might be placed in a modified *Buffonella* Jullien, in which the surface of both the zoarium and the ovicell is imperforate, also there is a small suboral avicularium, and the opercula have the muscular attachments some distance from the border as in the last group. It is represented by *S. ridleyi* MacG., *S. simplex*

I consider that the chitinous operculum was under the closure, and I should like to see the name operculum confined to the movable chitinous appendage. Levinsen on Plate i. figs. 15, 16, shows *Meliceritites vielbanci* d'Orb. with tubules to the closures, such as I have seen in recent Cheilostomata, and a number of similar closures are figured. Without there being perhaps any wide divergence of view I should not describe these as being regenerated zoecia, for while Levinsen has described regenerated zoecia, I have not seen anything to suggest their being common, and further, although we know that the polypides are regenerated in the closed zoecia, this by no means always takes place, as, for example, in the older parts of stems and when there is more than one layer. It therefore seems unadvisable to speak of them as regenerated zoecia when they are frequently permanently closed.

I have suggested to Professor Levinsen that the sunk walls with few openings as in *Meliceritites magnifica* (op. cit. Pl. i. fig. 7), may be comparable with the perforated wall or closure UNDER THE OPERCULUM in *Vittaticella* (see page 484). These are also to be compared with the partial closure I described in *M. rozana* Waters, Ann. Mag. Nat. Hist. ser. 6, vol. viii. pl. vi. figs. 2, 6 (1891). Levinsen in his most valuable work has given full figures and descriptions of the structure of Melicerititidae, and as I believe that many analogous structures are found in the Cheilostomata, a thorough examination of the closures of living forms is much to be desired.

\* Waters, Report on Sudanese Bryozoa, p. 254.

† Waters, Résultats du Voyage du S.Y. Belgica, "Bryozoa," p. 42 (1904).

d'Orb., *S. rimosa* Jull., *S. marsupifera* Busk, *S. tumida* H., *S. levata* H., *S. levigata* Waters.

It is quite clear that there are several groups that can be separated off from the old *Schizoporella*, but until more living and spirit specimens have been examined important characters remain unconsidered.

*Loc.* Since I gave the localities of *S. nicea* Miss Thornely has reported it from Amiraute, 29 fath.; Seychelles, 39 fath.; Providence, 50-78 fath. It was procured from Wasin, Brit. East Africa, 10 fath. (501); Ras Osowamenbe, Zanzibar Channel, 10 fath. (504); Prison Island, Zanzibar Channel, 10 fath. (505), and with the large mucro from Wasin, 10 fath., which may have to be called var. *wasinensis*: collected by Crossland.

#### SCHIZOPORELLA MONTFERRANDI Audouin.

*Lepralia montferrandi* Waters, Rep. Mar. Biol. of the Sudanese Red Sea, "Bryozoa," Journ. Linn. Soc., Zool. vol. xxxi. p. 171, pl. xvii. figs. 15-18 (1909). To which add:--

*Schizoporella pachnoides* MacG. Trans. Roy. Soc. Vict. vol. xxiii. p. 180 (1886); Prod. Zool. Victoria, dec. xix. p. 314, pl. 186, fig. 6 (1889).

This must go to *Schizoporella* as now limited (see p. 505). It is closely related to *S. galeata*, but as I have said they must probably be separated.

Add:—*Loc.* Victoria (MacG.). Wasin, Brit. East Africa, 10 fath. (520), collected by Crossland.

#### GEMELLIPORA PROTUSA Thornely. (Pl. LXX. figs. 4-6.)

*Gemellipora protusa* Thornely, Ceylon Pearl-Oyster Fisheries, vol. iv. Polyzoa, p. 119, pl. iv. fig. 7 (1905).

Zoarium incrusting. Zoecia rhomboidal, raised, with pores round the border; surface with few pores and granular. Oral aperture clithriate, very long, with large lateral contractions, and the peristome frequently much raised, especially at the side. At one side of the zoecium directed downwards a short wide triangular avicularium with a stout bar, and sometimes a second roundish avicularium near to the side of the aperture. Ovicell small, raised, globose, with very thick walls, perforated, much open in front and not closed by the operculum.

*Loc.* Gulf of Manaar (Th.). Wasin, Brit. East Africa, 10 fath., received dry (520), collected by Crossland.

#### TRYPOSTEGA VENUSTA Norman.

*Lepralia venusta* Norman, Ann. Mag. Nat. Hist. ser. 3, vol. xiii. p. 84, pl. x. figs. 2, 3 (1864).

*Schizoporella venusta* Hincks, Brit. Mar. Poly. p. 276, pl. xxx. figs. 6, 7 (1880); Kirkpatrick, Ann. Mag. Nat. Hist. ser. 6, vol. i. p. 76 (1888); "Hyd. & Polyzoa from the China Sea," Ann. Mag.



Nat. Hist. ser. 6, vol. v. p. 17 (1890); Proc. Roy. Dublin Soc. n. s. vol. vi. p. 612 (1890); Calvet, Expéd. Scient. du Travailleur et du Talisman, vol. viii. p. 416 (1907).

*Trypsetega venusta* Levisen, "Studies on Bryozoa," Vid. Medd. f. d. Naturh. Foren. i Kjøbenhavn, p. 23 (1902); Morph. & Syst. Studies on Chil. Bry. p. 281, pl. xix. figs. 1 a-1d, pl. xxii. figs. 13 a-13 d (1909); Norman, "Polyzoa from Madeira," Journ. Linn. Soc., Zool. vol. xxx. p. 299 (1909).

*Gemellipora glabra*, form *striatula* Smitt, 'Floridan Bryozoa,' pt. ii. p. 37, pl. xi. p. 207 (1873); Thornely, "Mar. Poly. Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 149 (1912).

*Gemellipora striatula* MacG. Prod. Zool. Vict. dec. xiv. p. 150, pl. 138. fig. 10 (1887).

*Lepralia striatula* MacG. Tr. Roy. Soc. Vict. p. 134, pl. iii. fig. 17 (1882).

*Schizoporella striatula* Waters, Q. Journ. Geol. Soc. vol. xli. p. 301 (1885); Philipps, "Poly. Loyalty Isles, &c.," Willey's Zool. Results, pt. iv. p. 440 (1899).

*Mollia tuberculata* d'Orb. Paléont. Franç. p. 388; see Waters, Ann. Mag. Nat. Hist. ser. 7, vol. xv. p. 6.

*Lepralia inornata* Gabb & Horn belongs to this group.

I should have hesitated, at present, to put this in a new genus merely on account of the small chamber above the zoecium, which no doubt must be considered as a vestigial avicularium, but as a genus may be required it will now cause less confusion to use Levisen's name. *Lepralia turgescens* Reuss, "Foss. Bry. Oest.-Ung. Miocènes," Denk. K. Akad. der Wissensch. Wien, math.-naturwiss. Class., vol. xxxiii. p. 36, pl. viii. fig. 7, has an avicularium, which, judging from the figure, corresponds to the small chamber above the zoecium in *T. venusta*, and also the avicularium of *Chorizopora brongiarti* Aud. is often similarly situated.

Sections of the specimen from Wasin show that there are no bands of muscles in the chamber above the zoecium, but there are protoplasmic bands to the frontal disk, starting from two rosette-plates at the proximal end of the small chamber, and near the distal end there is a small group of cells at each side, which must probably be considered as glands. There are a few irregular large chambers almost as large as the ordinary zoecia closed in the same way as these small supra-zoecial chambers.

There are but few ovarian cells in the ovary, usually two, sometimes three or four, and one may be seen developed to a considerable size. The embryos develop fully in the ovicell. No suboral glands have been found.

*Loc.* British; Guernsey; Calvados; Florida; Madeira (*Norman*); Azores; Cape Verde Islands (*C.*); Lifu, Loyalty Isl. (*Ph.*); China Seas (Tizard Bank), 27 fath.; Torres Straits (*K.*); Amirante, 22-85 fath., Saya de Malha, 29-125 fath. (*Thornely*); Mauritius. Wasin, Brit. East Africa, 10 fath. (500), collected by Crossland.

*Fossil.* River Murray Cliffs, South Australia.

## ARTHROPOMA CECILII Audouin.

*Flustra cecilia* Aud. 'Zool. Egypte,' p. 66 (239), pl. viii. fig. 3; see Miss Jelly's catalogue.

*Arthropoma cecilia* Levinsen, Morph & Syst. Studies on the Cheil. Bry. p. 332 (1909).

*Schizoporella cecilia* Thornely, "Mar. Poly of the Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 147 (1910).

In my Report of the Antarctic Bryozoa from the Voyage du S.Y. Belgica, p. 50, I called attention to this group and now Levinsen has given it a name. As I previously said *Phonicosia* Jullien may belong here, but Jullien's specimens are not sufficiently complete to settle the question.

*Loc.* Distribution general in the north temperate zone, the tropics, and Australia. Prison Island, Zanzibar Channel, on the shore (513), collected by Crossland.

*Fossil.* European and Australian Tertiaries.

## OSTHIMOSIA ZANZIBARIENSIS, sp. n. (Pl. LXXIII. figs. 9, 15.)

Zoarium incrusting seaweed, small, irregular. Zoecia subglobose, smooth. Oral aperture with distinct sinus, otherwise nearly circular, a small semicircular avicularium at each side of the aperture, and when there is an ovicell usually a second pair of avicularia. Surface of the zoecia imperforate with longitudinal ribs in the older zoecia, vicarious avicularia among the zoecia having expanded spatulate mandibles. Ovicell large, wide, globose, perforated all over.

In having the perforated ovicells this is like *Cellepora avicularis* Hincks, to which it is closely allied, but the median avicularium is absent. A perforated ovicell occurs in *C. avicularis* H., *C. coronopus* B., *C. megasoma* MacG., *C. conica* Busk, *C. redoutii*\* Aud. In the early stages this form resembles *Schizoporella biaperta* Mich., but vicarious spatulate avicularia are unknown in *S. biaperta*. The operculum is thinner than that of *C. conica*, and the walls also are thinner. I find that *C. conica* is the young form of a species determined by Busk as *C. simonensis*† B., an erect cylindrical species. The oral aperture of both *C. conica* and *C. avicularis* is slightly larger than that of this species from Prison Island.

After removing from *Cellepora* the genera *Holoporella* and *Lagenipora* there is the present group with a triangular sinus, the ovicell perforated and the surface of the zoecium imperforate except near the border, and the group includes *C. avicularis* H., *C. conica* Busk, *C. coronopus* S. Woods, leaving still another group with imperforate ovicells, but a small semilunar area or mark near the proximal part, and a marked sinus in the oral aperture, as, for example, *C. exesa* Jull., *C. eatonensis* B.

\* This is only a variety of *C. avicularis* H. I have a specimen from a sounding-line in the Red Sea.

† Waters, Zool. Chall. Exp. vol. xxxi. pt. lxxix. p. 35 (1899).

Hincks in his 'Brit. Mar. Polyzoa' says that the type of *Cellepora* was *pumicosa*, but this is not the case, for as Levinsen points out in his large work, Linnæus refers to *C. ramulosa* as the first species of *Cellepora*. Hincks incorrectly considered it the genus of Fabricius. Levinsen is, however, mistaken in supposing that *C. ramulosa* is schizostomous, as it belongs to the holostomatous group, though not to *Holoporella* \*. I have not as yet had any opportunity of cutting sections of *C. ramulosa*, but the operculum has the proximal border but slightly curved, and the small muscular attachments are close to the thicker part of the border. In most *Holoporellæ* the attachment is a little nearer to the edge, on the other hand it is much closer to the distal edge than is usual in the Schizostomous groups.

The ovicell of *ramulosa* is cap-like as in *Holoporella* etc., and although Hincks says perforate or imperforate, none of the specimens in my collection, nor any in the British Museum general collections, including Busk's and Hincks's, have a perforate ovicell; also in the Norman collection a few from each locality were examined without finding any perforate. There are two or three species externally corresponding with *C. ramulosa*, so that a mistake is easily made, and in three cases friends have sent me specimens so marked, of which only a part were *ramulosa*.

By taking (even if provisionally) *C. ramulosa* as definitely described by Hincks, and perhaps by some before him, as the type of *Cellepora*, we get out of a difficulty, for when *Schismopora* was created by MacGillivray *Cellepora* remained for the holostomous division. *C. ramulosa* is the first of Linnæus' species, the others being *spongites*, *pumicosa*, *ciliata*, *hyalina*. Linnæus' description of *ramulosa* would do for several species of branching forms, and we are doubtful what the other species were meant for. In Linnæus' copy of the 12th edition of Syst. Naturæ, there is in his small writing, under *C. ramulosa*, a reference "nidros pl. i. fig. 6," which was hieroglyphic to me until Dr. Daydon Jackson kindly explained that it referred to Det Kongelige Norske Videnskabets Selskabs Skriften, 4th part, 1768-1774, in which there is a paper by Gunnerus, who supplied Linnæus with both *C. ramulosa* and *C. pumicosa*. In this work (pl. i. fig. 6) is a figure of a *Cellepora*, which, judging from the locality, "Oceano Norvegico," is probably † *C. incrassata* Sm., although *C. coronopus* S. Woods, an entirely different species from the Mediterranean, corresponds equally well with this figure, which shows nothing but zoarial shape. It is, however, what Linnæus described as *C. ramulosa*. On the same plate the figure 7 shows a similar growth, though with smaller branches, and to this under *C. pumicosa* Linnæus refers by a

\* There are various species of holostomous Bryozoa which do not belong to *Holoporella* Waters, as, for instance, *C. sardonica* Waters, which will fall into *Holoporellidæ*.

† Waters, "Bry. from Franz Josef Land," Journ. Linn. Soc., Zool. vol. xxviii. p. 94 (1900).

similar note. A long time ago I showed\* that the *C. pumicosa* as we have understood it had nothing whatever to do with *C. pumicosa* L., as it does not in any way correspond with Linnaeus' description, besides which he refers to a figure by Marsigli which probably is a figure of *C. coronopus*. I then referred to it as *C. pumicosa* Busk (*non* L.) and have continued to do so. Fig. 7 may be a figure of *C. ramulosa* Hincks, etc. though called *pumicosa* by Linnaeus; there are, however, several other species that it might represent. After this record of mistakes about two well known species, showing how little we can know what the earlier writers meant, we should be allowed to return to our senses, and use these long established specific names for thoroughly described and well recognised species, namely *C. pumicosa* Busk, *C. ramulosa* Hincks, but if we retain *Cellepora* for *ramulosa* the *C. pumicosa* Busk becomes *Osthimosia* Jullien. This group was divided off in the same year by Jullien as *Osthimosia*, and as *Schismopora* by MacGillivray, but it seems that Jullien's name was published a few months the earlier. The opercula of this group are all of the same type, with the opercular attachment some distance from the border of the operculum. The group is left by Levinsen under *Cellepora*, through misunderstanding *C. ramulosa*. The ovicell of *Osthimosia* is, at any rate, nearly always punctured.

This leaves the *Cellepora* of Hincks divided into Holoporellidæ (holostomatous), and the schizostomatous forms into *Osthimosia* and *Lagenipora*.

*Loc.* Prison Island, Zanzibar Channel, 8 fath. (505); Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

#### LAGENIPORA ROTA MacGillivray.

*Cellepora rota* MacG. Trans. Roy. Soc. Vict. vol. xxi. p. 116 (11) pl. iii. fig. 6 (1885); Prod. Zool. Vict. dec. xv. p. 184, pl. 148. fig. 3 (1887).

Levinson would call this *Siniopelta*, but it is what I have previously put under *Lagenipora*, as the position and character of the ovicells of *L. socialis* Hincks seem to me to be the same as in the group which Levinson calls *Siniopelta*. As Levinson has not agreed with me, I have also, besides again examining the British Museum specimens, through the kindness of Professor Hickson, examined the specimens from Miss Jelly's collection in the Victoria University Museum. Miss Jelly first found *L. socialis* in Hastings, and presumably all known Hastings specimens were collected by her. The Hastings specimens in the Victoria Museum did not show the ovicell, but one so named by Miss Jelly, from Guernsey, has some ovicells and also shows the spinous processes well.

The ovicell of the Guernsey specimen is situated on the wall

\* Waters, "Bryozoa of the Bay of Naples," Ann. Mag. Nat. Hist. ser. 5, vol. iii. p. 198 (1879).

of the peristome, which frequently extends beyond it as a complete tube, and the ovicell has an area which is flat or slightly rounded and is surrounded by a ridge, while at each corner inside the ridge there is a pit. It seems justifiable to call the part surrounded by the ridge an area, but if there is any objection to this it might be called a tabula. In this case the "calcareous base" is very slightly developed and might be overlooked, and except that the Guernsey specimen is slightly granular or rather nodulated there is but little difference between it and *Lagenipora lucida* Hincks from Madeira, except that *L. lucida* has pores round the area as figured by me\*, but I have not the opportunity of now comparing any *L. lucida* having ovicells.

Now in *Lagenipora nitens* MacG. from Port Phillip Heads, which I considered only a variety of *lucida*, the ovicell is just the same shape and in the same position, while close to the ridge of the area there is a row of pores; also *L. boryii* Aud. from the Mediterranean has a row of pores in the same place, whereas in *L. rota* MacG. and some other species there are radiating grooves. An Australian species of *Lagenipora* has the area evenly perforated all over. The pores or pits of *L. socialis*, though difficult to trace, are no doubt small and close to the edge. When I first thought I saw pores it was puzzling not to find a complete row, and there was a doubt whether they might only result from accidental damage, but no doubt the explanation is that there is only one at each corner. There must be something wrong if *Lagenipora socialis* and *L. lucida* are placed in different genera.

*Loc.* Victoria (*MacG.*). Wasin, Brit. East Africa, 10 fath. (507), collected by Crossland.

#### HASWELLIA AUSTRALIENSIS Haswell.

*Myrionozoum australiense* Haswell, Proc. Linn. Soc. N.S. Wales, vol. v. pt. 1, p. 43, pl. iii. figs. 9-11 (1880).

*Haswellia australiensis* Busk, "Polyzoa," Zool. Chall. Exp. vol. x. pt. xxx. p. 172, pl. xxiv. fig. 9 (1884); Kirkpatrick, Proc. Roy. Dublin Soc. vol. vi. p. 612 (1890); Meissner, M., aus Semon "Zool. Forsch. Reisen in Australien und Malay," Jena. Denkschr. vol. viii. p. 731 (1902); Levinsen, Morph. & Syst. Studies of the Cheil. Bryozoa, p. 297, pl. xvi. figs. 2 a-2 b (1909).

*Porina coronata* var. *labrosa* Waters, Zool. Chall. Exp. vol. xxxi. pt. lxxix. p. 32 (1889).

Levinson places this in Myrionozoidæ†, but it seems somewhat doubtful whether the genera grouped together by Levinson will remain in the same family (see p. 520).

The series of zoecia in *H. australiensis* are all on the same horizon, and usually at the beginning of each branch there are six zoecia in a whorl, there is then another whorl with six, then one with eight when a bifurcation takes place, and then again

\* Journ. R. Micr. Soc. 1899, p. 13, pl. iii. figs. 25, 27, 30 (1899).

† *Loc. cit.*, see page 296.

each of the new series commences with six. *H. australiensis* has 19-21 tentacles. Unfortunately none of the specimens now examined have ovicells. The *Haswellia* group is well represented in the North Italian Tertiaries, and although some appear to be almost identical with living species, it seems better to keep them distinct, as all the structures cannot be compared.

There is over the surface an outer membrane, and then under this there are membranes of the two walls of the shell showing when decalcified the position of the pore-tubes. Some specimens from Wasin have a pink colour.

The operculum of the species and of the *H. coronata* H. or *H. gracilis*, whichever we may have to call it, is identical, having the opercular attachment very high up and elongate (see my figure in Ann. Mag. Nat. Hist. ser. 5, vol. xx. pl. vi.). The operculum of *H. auriculata* B. has the muscular attachments much lower down and not so near the edge; further, the ovicell which is but slightly raised, has a semicircular area, and the surface of the zocæcium has not pores all over. It seems exceedingly doubtful whether *H. auriculata* should remain in *Haswellia*, but I have never had sufficient material in my hands for a complete examination. *H. grandipora* Waters is *Haswellia*, and I now think must stand as a species.

*Loc.* Holborn Island, Queensland (*Hasw.*); near Torres Straits (*Chall.*); Thursday Island, Torres Straits (*Meissner*); Formosa Channel (*Levinson*). Wasin, Brit. East Africa, 10 fath. (500, 501, 507, 520), collected by Crossland.

#### TUBUCELLARIA CEREOIDES, var. CHUAKENSIS Waters.

*Tubucellaria cereoides* var. *chuakensis* Waters, "Tubucellaria," Journ. Linn. Soc., Zool. vol. xxx. p. 130, pl. xv. figs. 10-13, 18, 19, pl. xvi. figs. 20-25 (1907); Thornely, "Mar. Poly. Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 146 (1910).

*Tubucellaria fusiformis* Busk (*non* d'Orb.), Zool. Chall. Exp. vol. x. p. 100 (1884).

*Loc.* Torres Straits (*Busk*); Grahamstown, S. Africa; Providence, 50-78 faths. Chuaka, Zanzibar, 3 fath. (512, 524); Wasin, Brit. E. Africa, 10 fath. (501); Chaki-Chaki, Pemba Island (517), low water, collected by Crossland.

#### TUBUCELLARIA FUSIFORMIS d'Orbigny.

Waters, *loc. cit.* p. 131, pl. xv. figs. 1, 2, 3, 14.

*Loc.* Malacca, Amirante Is., Chuaka, Zanzibar, 3 fath. (528); Wasin, Brit. East Africa, 10 fath. (520), collected by Crossland.

#### TUBUCELLARIA ZANZIBARIENSIS Waters.

Waters, *loc. cit.* p. 131, pl. xv. figs. 4-7; Thornely, "Mar. Poly. Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 146 (1912).

*Loc.* Saya de Malha, 145-150 faths.; Farquahar Reef;

Cargados, 28 fath. Wasin, Brit. East Africa, 10 fath. (501); Ras Osowamembe, Zanzibar Channel, 10 fath. (504, 514); Prison Island, Zanzibar Channel (505); Chuaka Bay: collected by Crossland.

*SMITTINA TRISPINOSA*, var. *PROTECTA* Thornely.

*Smittia trispinosa*, var. *protecta* Thornely, Ceylon Pearl-Oyster Fisheries, vol. iv. Polyzoa, p. 123 (1905); Waters, "Mar. Biol. of the Sudanese Red Sea," Journ. Linn. Soc., Zool. vol. xxxi. p. 173, pl. xvii. figs. 5, 6 (1908).

*Smittia nitida* Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. vii. p. 159, pl. ix. fig. 5 (1881).

There are two specimens with the large avicularia situated diagonally distal to the oral aperture. The ovicells of this variety and of typical *nitida* are similar, and there are some specimens with a large, almost spinous, process at the proximal part of the peristome, with a similar process on the ovicell just distal to the area of pores. An identically similar form occurs off the Cape Verde Islands, and Osburn \* mentions an umbo in some forms of *nitida* "behind the orifice," and he shows how *S. trispinosa* var. *nitida* is subject to great variation with regard to the avicularia and the peristome.

Loc. Gulf of Manaar (*Th.*); "Africa" (*J.*); Red Sea (*W.*). Wasin, Brit. E. Africa, 10 fath. (520), collected by Crossland.

*SMITTINA TRISPINOSA*, var. *SPATHULATA* MacGillivray.

Waters, "Mar. Biol. Sudanese Red Sea," Journ. Linn. Soc., Zool. vol. xxxi. p. 156.

The ovicell has a distinct area, the border of which sometimes rises as an umbo, or is divided into two sharp, erect processes. *S. trispinosa* var. *bimucronata* Hincks belongs to this group, but it is doubtful whether it should be separated as a variety, as there is normally such considerable variation in the zoecia. From (504) there are very large vicarious avicularia, directed either distally or proximally.

*Smittina* is used instead of *Smittia*, though not including all that Levinsen refers to it, for I consider it a group in which the operculum is usually very thin, almost membranous, with the lower edge straight. In the species so far examined, the oral glands are quite small and usually more or less attached to the tentacular sheath. In the aperture a lyrula is usually found with the operculum under the cardellæ but over the lyrula. *Pseudo-flustra solida* Stimp., and *Lepralia pallasiana*, together with its allies, show many differences and do not seem to belong here.

Loc. Bass's Straits; Torres Straits; Red Sea. Wasin, Brit. E. Africa, 10 fath. (520); Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

\* "The Bryozoa of the Woods Hole Region," Bull. Bur. of Fisheries, vol. xxx. p. 246 (1912).

## SMITTINA TROPICA Waters.

*Smittina tropica* Waters, "Mar. Biol. of the Sudanese Red Sea," Journ. Linn. Soc., Zool. vol. xxxi. p. 174, pl. xvii. figs. 10-14 (1909).

*Loc.* Red Sea. Wasin, 20 fath. (520), collected by Crossland.

## SMITTINA sp.

There is a small piece of *Smittina* encrusting *Adeonella platealea*, which has the peristome very much raised, especially at the distal part, and there is apparently a triangular avicularium in the lip. There are perforations round the border of the zoecium, and the small ovicell is not much raised and is at the base of the peristome, and at each side of the ovicell close to the edge there is a small clear spot. There are two openings in the ovicell of *S. oculata* MacG., and sometimes others; and I find in a specimen sent me by Jullien as *S. longirostris* J., there is a similar spot at the side of an ovicell. Jullien's species has large frontal avicularia, whereas none are found on the small fragment. The lyrula is at first very narrow but spreads out widely on each side. I hesitate to give it a name until better specimens are found.

*Loc.* Ras Oswamembe, Zanzibar Channel, 10 fath. (504).

## LEPRALIA FEEGENSIS Busk. (Pl. LXX. figs. 21, 22.)

*Lepralia feegensis* Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 144, pl. xxii. fig. 9 (1884); Philipps, in Willey's Zool. Results, pt. iv. p. 446, pl. xliii. fig. 7 (1889); MacGillivray, Proc. Roy. Soc. Vict. n. s. vol. iii. p. 81, pl. x. figs. 1, 2 (1891); Thornely, Ceylon Pearl-Oyster Fisheries, vol. iv. p. 121 (1905); Rec. of Indian Mus. vol. i. pt. 3, no. 13, p. 190 (1907); "Mar. Polyzoa Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 150 (1912).

*Hippopodina feegensis*, Levinsen, Morph. & Syst. Studies on the Cheil. Bry. p. 353, pl. xxiv. figs. 3 a-3, f (1909).

Miss Philipps described and figured the ovicell as with opaque granulations, globular and depressed; and Miss Thornely, not aware that the ovicell had been seen, described it as with large circular pitted areas punctured in their centres. In a specimen in my collection, from "Singapore or Philippines," the ovicell has the pores fairly similar to, and about the same size as, the pores of the zoecia. MacGillivray had previously described the ovicell of his *L. feegensis*, but as the avicularium, which is directed downwards, is in quite a different position, I doubt whether it is the *feegensis* of Busk. He described the ovicell as large, rounded, prominent, and marked similarly to the zoecia. In the specimens from Zanzibar (501) there are no ovicells, glands, ovaria, or testes, but in those from (511) there are many ovicells which are perforated, though when the ovicell contains an ovum or embryo these perforations look dark and opaque.

There are about 26 tentacles, and the operculum closes the ovicell. There are several ovarian cells in an ovary.



In the submandibular part of the avicularium there is a hammer-shaped thick chitinous piece for attachments of muscle. The proximal muscles are in several bundles and are attached to the base of the tentacles.

*Lepralia* is a genus which we have long wanted to see brought into order, but certainly further work is required. Hincks made a group *Lepralia*, and, no doubt, on the whole the species of his group are closely related, but he unquestionably placed some there which should have gone in his *Schizoporella* and other genera. Neviani, taking species with a horse-shoe aperture, made a genus *Hippoporina*, but he still retained some which must be separated, and very little was gained by his new name. In *Lepralia* the operculum is usually thick and has a strengthening band at each side with the muscles attached near the distal end of the band. The sides of the operculum are either straight or much contracted where the lateral teeth of the aperture occur. This will remain a fairly large group even when extraneous species have been removed, but we hardly know where Levisen would place them, as hardly any of them are mentioned. *L. adpressa*, *L. hippopus*, *L. rectilineata* Hincks, find no place. *Lepralia feegensis* is made the sole representative of a new genus *Hippopodina*, but the characters given seem insufficient for separation, as there are a considerable number with the same general characters.

Some *Lepralia* Levisen places under *Smittia*, a new name for *Smittia*, but the true *Smittia* to which he alludes have a very thin membranous operculum with straight proximal edge hardly separated from the frontal membrane, and there is usually a lyrula, which is perhaps a structural correlation with the thin membranous operculum; further, there are very small oral glands often partly attached to the tentacular sheath. I find it quite impossible to place *Lepralia pallasiana* and its allies side by side with *Schizoporella auriculata* Hass., *S. linearis* Hass., *S. triangula* Hincks, etc., as the group seems very unnatural.

Levisen's *Cheilopora*\* contains species some of which have the ovicelligerous zoecia with a quite differently shaped aperture from that of the ordinary zoecia, as, for instance, *Lepralia circumcincta* Neviani, a species found fossil, but also living, from Naples, Capri, and Oran (Algiers); whereas *L. longipora* MacG. = *L. prelonga* Hincks, and *L. praelucida* H. have large raised perforated ovicells. This dimorphism occurs in several Lepraliidae, but in Schizoporellidae I only remember it in *S. subimmersa* MacG. We hardly know yet how far these characters are reliable for generic divisions.

Such forms as *L. adpressa* Busk, *L. hippopus* Sm., *L. rectilineata* H., and the bulk of what we have known as *Lepralia* should remain there until ample living and spirit material of numerous specimens has been examined.

\* Haime made a genus *Chilopora* and Michelotti called one *Cheilopora*.

*Loc.* Philippines, 18 fath. (*Chall.*); Singapore or Philippines (*A. W. W. coll.*); Hong Kong; Lifu (*Ph.*); Manaar (*Th.*); Andamans (*Th.*); Cargados (Ind. Ocean) (*Th.*); (?) Nichol Bay, N. W. Australia (*MacG.*). Wasin, Brit. East Africa, on *Adeonella*, 10 fath., from bottom of s.s. 'Juba,' which always remains in Zanzibar waters (511), collected by Crossland.

LEPRALIA TURRITA Smitt. (Pl. LXXIII. fig. 10.)

*Lepralia turrita* Smitt, Floridan Bryozoa, pt. ii. p. 65, pl. xi. figs. 226-228 (1873); Kirkpatrick, Ann. Mag. Nat. Hist. ser. 6, vol. v. p. 16 (1890); Thornely, "Mar Poly. of the Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 150 (1912).

The small specimen from Wasin has four long calcareous spinous processes, irregularly placed round the aperture. One or more of these processes may bear an avicularium at one side near the base, as in the spinous process of *H. albirostris* Sm. Besides these avicularia there are on the surface of the zoarium numerous small semicircular avicularia, irregularly scattered. The ovicell is not much raised and has an elongate elliptical opening in the front. A specimen of *Lepralia turrita* in my collection has short blunt processes with similar semicircular avicularia, and the ovicell, which is more raised, has a similar wide opening in the front. Perhaps, on account of the different character of the ovicell, it should at least be made a variety, but until more material is available it is allowed to stand.

The operculum has the sides nearly straight with the proximal edge curved; there are two muscular dots a little distance from the edge and two articular thickenings; the width is about 0.2 mm. This operculum does not correspond with any with which I am acquainted, for though in many respects it is like those of what I should call, in a restricted sense, *Lepralia*, there is no lateral ridge for the muscular attachment, which is not close to the border.

In the British Museum there is a specimen marked *turrita*, which is *Holoporella*, and it seems as if there were more than one with a series of calcareous processes round the oral aperture. What Ridley and what I called *L. turrita* may each have to be placed elsewhere.

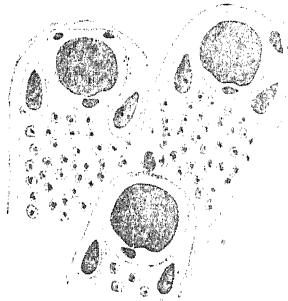
*Loc.* Ascension Island; Florida (*Sm.*); China Seas; Amirante, 29 fath.; Cargados, 30 fath. Wasin, Brit. East Africa, 20 fath. (522), collected by Crossland.

LEPRALIA WASINENSIS, sp. n. (Text-fig. 81.)

A small piece with only seven zoecia was found on re-examining some material, when the paper was almost completed. Only the calcareous part remains, which was probably bilaminar, but this cannot be stated with certainty. The zoecia have the sides straight and the distal end somewhat rounded, with thick borders to the zoecia. The oral aperture is subrotund with a wide curve on the distal end surrounded by a thick band. The frontal

surface is closely pitted, and at each side of the oral aperture, somewhat below it, there is a large subtriangular chamber which is probably avicularian. In the band surrounding the oral aperture there is an opening at the proximal end which appears to be avicularian.

Text-fig. 81.

*Lepralia wasinensis*, sp. n.  $\times 25$ .

The species seems most nearly related to *Lepralia* (*Mucronella*) *præluclida* Hincks, which has a large avicularium by the side of the oral aperture as seen in my specimens, and as Professor R. Osburn \* mentions in his specimens from Labrador.

*Loc.* Wasin, Brit. East Africa, 20 fath. (520), collected by Crossland.

*LEPRALIA CLEIDOSTOMA*, var. *INERMIS* Ortmann.

*Lepralia cleidostoma*, var. *inermis* Ortmann, "Die Japanische Bry.," Archiv für Naturgesch. vol. i. p. 49 (1890).

*Lepralia cleidostoma*, var., Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. xiii. p. (41) (1884).

This form has the surface smooth and silvery with frequently an umbo below the aperture and often one on the ovicell. The ovicell is scarcely at all raised and is also smooth and imperforate, and has a small semilunate area. There is sometimes a small knob on each side of the aperture. Both the aperture and the operculum are about the same size and form as that of *L. cleidostoma* Smitt from Madeira †, which also occurs at Florida (*Sm.*), Japan (*Ort.*), and Bermuda (*my coll.*); but *L. inermis* var. differs in having no avicularia, and it is a question whether it is advisable to consider it a species or a variety.

Norman says ‡ that *L. cleidostoma* is the *L. porcellana* Busk, but

\* "Bryozoa from Labrador, etc.," Proc. U.S. Nat. Mus. vol. xliii. p. 283, pl. xxxiv. figs. 3, 3a, 3c (1912).

† Waters, "Bryozoa from Madeira," Journ. R. Micr. Soc. 1899, p. 10, pl. iii. fig. 16.

‡ "Polyzoa of Madeira," Journ. Linn. Soc., Zool. vol. xxx. p. 305, pl. xl. figs. 1, 2 (1909).

as it has been impossible to recognise it from Busk's figures the name *cleidostoma* must stand.

*Loc.* Queen Charlotte Island (*Hincks*); Japan, 100 fath. (*Ortmann*). Wasin, Brit. East Africa, 10 fath. (520), collected by Crossland.

PETRALIA JAPONICA Busk.

*Lepralia japonica*, Waters, Mar. Biol. of the Sudanese Red Sea, Journ. Linn. Soc., Zool. vol. xxxi. p. 149, pl. xiii. figs. 10-12.

*Loc.* Add (Natal, as *Hemeschard gigantea* Busk MSS. in the Brit. Mus.) Wasin, Brit. East Africa, 10 fath. (501), collected by Crossland.

PETRALIA CHUAKENSIS, sp. n. (Pl. LXX. figs. 10-14.)

Specimens from Chuaka correspond in most particulars with Busk's description of *Lepralia dorsiporosa*\*, but the notch at the distal end of the zoeecium is wanting, and in *chuakensis* the proximal edge of the aperture is serrate. The avicularium at the side is curved and is larger than those figured by Busk. The Zanzibar specimens have ovicells which are unknown in *dorsiporosa*, and the wall, which is not much raised, is finely perforated.

The perforated area in the dorsal surface is for a broad radicle, which, however, is not always developed; a similar area occurs in *Petralia vultur* var. *armata*, and also in *Petralia japonica* there is often a similar large radicle. Levinsen refers to the radicle tube in *P. dorsiporosa*. There is a complete bar to the avicularia often disappearing in Eau de Javelle preparations. There are numerous uni- or few-pored rosette-plates scattered over the distal wall. On the lateral wall, about halfway between the frontal and basal walls, there is a row of about 5 few-pored rosette-plates.

There are about 28 tentacles. In the ovarium there are but few ovarian cells.

It has been thought best to give a specific name, although there is much in common with *P. dorsiporosa* from the Torres Straits.

*Loc.* Chuaka, Zanzibar, 3 fath. (502), collected by Crossland.

PETRALIA VULTUR Hincks, var. ARMATA, nov. (Pl. LXX. figs. 15-20).

Type, *Mucronella vultur* Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. x. p. 98, pl. viii. fig. 2 (1882).

From Chuaka, Zanzibar, there are unilaminate specimens differing from the *Mucronella vultur* as described by Miss Thornely†, in having a triangular mandible to the avicularium attached to the mucro. There are also a large number of raised round avicularia, with semicircular mandibles, and a distinct cross-bar. These avicularia are sometimes on the top of a raised

\* Zool. Chall. Exp. vol. x. p. 143, pl. xviii. fig. 4.

† Ceylon Pearl-Oyster Fisheries, vol. iv, p. 124 (1905).

tube. There are a few large spatulate avicularia at one of the distal corners, and these also have a distinct cross-bar. Specimens of *M. vultur* in Miss Thornely's collection show the mandible serrate.

There is a fairly broad lyrula and two cardellæ, and the lyrula is formed before the front wall is complete. Only one ovicell has been seen, and that is partly broken, but it is broad and minutely perforated.

On the dorsal surface there are perforated spaces, no doubt for radicles, but there are usually several small ones instead of one large one as in *Lepralia dorsiporosa* B.

Similar ovicells with minute perforations occur in *Petralia undata* MacG., *P. japonica* Busk, *P. vultur* Hincks, *P. ellerii* MacG., *P. (Mucronella) magnifica* Busk, *P. (Escharella) bisinuata* Smitt (non Busk), *P. thenardii* Aud., *P. (M.) porosa* Hincks, *P. (M.) castanea* Busk, *L. crassa* Thornely; and these Levinsen would place in his family Petraliidae, and thus it would seem as though a genus can be separated based largely on the ovicell. In the species of this group which it has been possible to examine, there are a large number of tentacles, viz., *Petralia undata* MacG., about 26; *P. japonica* B., about 25; *P. castanea* B., about 23; *P. vultur* var. *armata*, nov., about 25; *P. chuakensis*, nov., about 25.

There seem to be two tentacles larger than the rest (figs. 15-17), and these, instead of being triangular, have the inner surface nearly straight, with a number of long nuclei. On this inner surface there are cilia, but unfortunately the condition does not admit of exact study of this point. These two larger tentacles occur in all the species examined of the group, and larger tentacles occur in other groups to which I have previously alluded. These large tentacles are most marked near to the base of the tentacles when they are commencing to divide, whereas nearer to the ends there is but little difference.

*Loc.* Chuaka, Zanzibar, 3 fath., 29.3.1901 (506), collected by Crossland.

#### ? *ESCHAROIDES OCCLUSA* Busk.

See ? *Lepralia occlusa* Waters, "Mar. Biol. of the Sudanese Red Sea," Journ. Linn. Soc., Zool. vol. xxxi. p. 152, pl. xiii. fig. 15, pl. xiv. figs. 1-9, 13 (1909).

The distal and lateral walls have numerous scattered uniporous rosette-plates, especially near the inner borders. At the side of the zoarium there are often two large spatulate opposite avicularia, whereas in *Adeonella* the avicularia are usually on a median line.

Levinson would put this under Myrionozoida, but I hardly think he can have had sufficient material before him when writing about the family, and that is often our difficulty in considering classification.

The type of *Myrizoum* must, of course, be *M. truncatum*, and I am not sure that any other living species can be put in the same genus. It has a large number of tentacles, 26-27, which should lead us to consider carefully whether the species with about 16 tentacles belong to the same genus, though we cannot conclude from that alone that they do not.

Levinson makes one of the characters of Myrizoidea, "dependent avicularia seem always to be present," but in the type *M. truncatum* no avicularium has been found; another of his characters of *Myrizoum* and *Myrizoella* is no transverse bar in the avicularium, but *Schizoporella biturrita* H. and what I have called *S. tuberosa* Rss. and *Escharoides oclusa* have a distinct bar. In *M. truncatum* the ovicell is a very large swelling with the covering wall resembling the zoecial wall. *S. crustacea* has a prominent round ovicell with radiating ornamentation. *S. biturrita* H. and *S. tuberosa* have very large wide raised ovicells. In *M. simplex* Busk no ovicell is externally apparent, though calcareous sections reveal a concealed ovicell. In *S. polymorpha* the ovicell is also under the calcareous wall, giving, as a rule, no external sign (see my suppl. 'Challenger' Rep. vol. xxxi. pl. ii. figs. 22, 23). In *S. biturrita* and *S. polymorpha* B. there is an avicularium at each side of the oral aperture, and in *M. mario-nensis* B., at each side well within the peristome, there is a small avicularium with a mandible rounded at the end.

Now, in ?*Escharoides oclusa* there is an avicularium on the lip of the peristome at one side\*, the ovicell is but moderately raised, with a few large openings, the avicularia have a bar and there are very large glands, at first paired, but often ultimately uniting to form a large multilobular gland. So far as my sections go, namely, *S. crustacea*, *M. coarctum*, *M. subgracile*, and *M. truncatum*, there are no glands in the species considered as Myrizoidea except in *E. oclusa*, and these are quite different from any others known. Also the general absence of glands indicates that Myrizoidea of Levinson are not, as considered by him, closely allied to the Reteporidae, in which glands are so well developed, and which usually have a sublabial pore and a lamina to the ovicells, also vibices indicating two distinct layers. The operculum of *E. oclusa* is quite different from that of any other species placed by Levinson under Myrizoidea. It has a thick border all round, and near the distal edge are two knobs for the attachment of the muscles. *Myrizoum truncatum* has a very large operculum of a shape quite different from that of the others mentioned, the proximal portion of the operculum being somewhat triangular with the attachments near to the proximal end. *M. subgracile*, *M. coarctum*, and *M. crustacea* have the sides of the moderate-sized operculum nearly straight, with the muscle near the side. *Haswellia australiensis* has the muscular attachment near the border of the

\* The position of the avicularium is similar in *Rhamphostomella*, etc., but we do not yet know the systematic value of this character.

operculum. *Myrionozoum marionensis* would seem to be *Cellarinella* or related to it. *Gephyrophora polymorpha* has a large operculum nearly round, with a wide vanna fitting into the poster, and the muscular dot is some distance from the edge, in fact it is of a Schizoporellidan character.

It seems probable that *E. occlusa* must be made the type of a new genus, and I expect that the examination of material suitable for cutting will result in a re-arrangement of classification of the Myrionzoidea of Levisen, as the ovicells present such great differences. I am loth to make new genera until we can see from sufficient material what is to be grouped together; at any rate, I fail to see good reason for placing *Escharoides occlusa*\* under *Myrionozoum*.

*Loc.* See Waters, "Red Sea Bryozoa" p. 156. Wasin, Brit. East Africa, 10 fath. (501) (520); Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

#### HOLOPORELLA COLUMNARIS Busk.

*Cellepora columnaris* Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 194, pl. xxix. fig. 11, pl. xxxv. fig. 16 (1884); Waters, Ann. Mag. Nat. Hist. ser. 6, vol. iv. pl. ii. figs. 1-6 (1889); Ortmann, "Die Japanische Bryozoenfauna," Archiv f. Naturgesch. vol. i. p. 55 (1890).

*Cellepora cidaris* MacG. Prod. Zool. Vict. dec. xvii. p. 243, pl. 165. fig. 4 (1888); Thornely, "Ceylon Pearl-Oyster Fisheries," vol. iv. Poly. p. 126 (1905); Records of Indian Museum, p. 195 (1907).

The oral aperture has a denticle at each side. As shown in my paper mentioned above, the columns are often very thick, extending through several layers of the zoarium. A specimen of *Holoporella* in my possession, named in manuscript *celosia* by Busk, has similar columns passing through several rows of zoecia, and the avicularian mandible has a double columella, while the shape of the operculum also shows that it is a distinct species. This is not, however, the species so named in the Busk collection in the British Museum, where there are two other species named *celosia*, MSS.

I have had the opportunity of comparing Busk's types and MacGillivray's co-types (*i. e.*, duplicates) in the British Museum, and there can be no doubt as to the identity of *columnaris* and *cidaris*.

In a specimen of *columnaris* from Wasin there are numerous small hydroids extending far into the zoarium within, protecting internal walls, formed by the *Holoporella*, prolonged slightly

\* Hincks considered *Escharoides*, a name given by Milne-Edwards for a subgenus of *Cellepora*, as being now the genus of Smitt, who used it for species with an avicularium in the lip on one or both sides, but Smitt never fully diagnosed it. As *Escharoides*, a name originally meaningless, has been used in a quite different sense from Levisen's, it would be much better if he recalled his genus *Peristomella* and used it instead of *Escharoides*.

beyond the zoarium. Sometimes they start from the base, and the polypides stand out from the upper surface of the zoarium. A similar case from the Red Sea is mentioned in the addenda to my Report\*. Probably the hydroids in both are *Clava*.

There are about 18 tentacles. There are a great number of ovaria with two small ovarian cells, and in only one or two cases has a moderate-sized ovarian cell been seen, and the ovaria are of the *Bugula* type. The ovaria may be surrounded by testes.

*Loc.* Bass's Straits, 38 fath. (*Chall.*); Port Phillip Heads (*MacG.*); Port Jackson, N.S.W. (*Waters*); Sagami-bai, Japan (*Ort.*); Manaar, 34 fath.; Ceylon Coast, 32-34 fath.; off Port Blair, 100 fath.; St. 59, 32 fath., St. 77, 35 fath. (*Thornely*). Wasin, Brit. East Africa, 10 fath. (501), collected by Crossland.

#### HOLOPORELLA APERTA Hincks.

Waters, "Mar. Biol. of the Sudanese Red Sea," "Bryozoa," Journ. Linn. Soc., Zool. vol. xxxi. p. 161, pl. xviii. figs. 20-23 (1909).

*Loc.* Additional. Wasin, Brit. East Africa, 10 fath. (500); Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

#### HOLOPORELLA ALBIROSTRIS Smitt. (Pl. LXXIII. fig. 11.)

*Cellepora albirostris*, forma *typica* Smitt, "Floridan Bryozoa," pt. ii. p. 70, pl. xii. figs. 234-239 (1873).

*Cellepora albirostris* Busk, Journ. Linn. Soc., Zool. vol. xv. p. 347, pl. xxvi. fig. 2 (*non* fig. 1) (1881); Zool. Chall. Exp. vol. x. pt. xxx. p. 193, pl. xxxiv. fig. 7, pl. xxxv. fig. 3 (1884); Waters, Quart. Journ. Geol. Soc. vol. xli. p. 304 (1885); op. cit. vol. xliii. p. 68 (1887); Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 197 (1887); MacGillivray, Prod. Zool. Viet. dec. xvii. p. 249, pl. 167. fig. 1 (1888); Mon. Tert. Poly. p. 109, pl. xiv. fig. 11 (1895); Thornely, "Mar. Poly. Indian Ocean," Trans. Linn. Soc., Zool. ser. 2, vol. xv. pt. 1, p. 155 (1912).

In *H. albirostris* there is great variation in the colour, some being very dark with the ends of the rostra white, others may be nearly white.

There are vicarious duck-bill avicularia and the border of the rostral avicularia is denticulate: the oral glands (fig. 11) are very long, and there are 16-17 tentacles.

A specimen is partly adnate, from which bilaminate branches arise. The unilaminate portions, when seen from below, are quite regular with the sides of the zoecia parallel, as in so many Schizoporellidae.

Both Smitt and Busk expressed doubt as to whether *H. albirostris* and *H. bispinata* were synonyms, but this is not the case, for *albirostris* has a long spine below the oral aperture, while *bispinata* has a short avicularium; further, in *H. albirostris* there

\* Journ. Linn. Soc., Zool. vol. xxxi. p. 254, p. 163, pl. xv. fig. 16 (1910).



is a pair of the minute avicularia at the side of the zoecium to which I referred in my Report of the Sudanese Bryozoa, but none were found in *H. bispinata*. Further, the operculum of *H. albirostris* has a muscular ridge turning sharply inwards and ending off short, whereas the operculum of *H. bispinata* has a ridge, very thick at the base, extending as a thin band nearly to the apex. *H. albirostris* has a very long oral gland nearly the length of the polypide, while the gland of *H. bispinata*, though also cylindrical, is much smaller.

*Loc.* Florida, 25–35 fath. (*Sm.*); Heard Island, 35 fath. (*Chall.*); New South Wales (*Waters*); Victoria (*MacG.*); Amirante, 12–18 fath. (*Thornely*). Wasin, B. East Africa, 10 fath. (501); Chuaka, Zanzibar, 3 fath. (525), collected by Crossland.

*Fossil.* Australia, N. Zealand (*W.*); Victoria (*MacG.*).

#### MICROPORELLA CILIATA Pallas.

*Loc.* Northern Seas; British; Atlantic; Mediterranean; Red Sea; Ceylon; Australasia and varieties in Japan, Australasia; Zanzibar (*H.*), the N. Indian Ocean. Wasin, Brit. E. Africa, 10 fath. (500), collected by Crossland.

*Fossil.* Pliocene and Miocene of Europe, and Tertiary of Australia and New Zealand.

#### RHYNCHOZOOON PROFUNDUM, var. LAMINATUM, nov. (Pl. LXXII. fig. 11.)

The specimens from Wasin may be the *R. profundum* as first described by MacGillivray, but it is not the *profundum* of the Prodromus, which MacGillivray considers is the same as *R. longirostre* Hincks.

The species of *Rhynchozoon* are difficult to distinguish, but the ovicell has a lamina in the front like the lamina of *Retepora*, to which it is related, and the shape of the lamina furnishes specific characters of value. In this Zanzibar variety the lamina is long and rounded at the end, whereas in *R. profundum* it is shorter, very broad, and spreads out at each side. In *R. bispinosum* Johns. it is quite short.

In this variety as in *R. profundum* the denticle is broad and uncinat, and the ovicell is but little raised above the general surface. There are narrow pointed avicularia over the surface, as usual in *Rhynchozoon*.

*Loc.* Wasin, Brit. East Africa, 10 fath. (520), collected by Crossland. Noumea (in *A. W. W.* coll.).

#### RETEPORA HIRSUTA Busk.

*Retepora hirsuta* Busk, Zool. Chall. Exp. vol. x. p. 119, pl. xxvi. fig. 4 (1884); Waters, "Mar. Biol. of the Sudanese Red Sea," Journ. Linn. Soc., Zool. vol. xxxi. p. 175, pl. xviii. figs. 24–26 (1909).

Specimens from (500) and (520), which are undoubtedly the

same as Busk's 'Challenger' *R. hirsuta*, have besides minute circular avicularia round the fenestræ, also on the inner side of each of the zoecia bordering a fenestra, an elongate avicularium with the beak bifurcate but with an acute mandible. This was described by Busk for *R. hirsuta* and is one of the most important characters. Large pieces were examined without finding any of the long antenniform spines described by Busk, and then in some places they were found in abundance. This is much like *R. monilifera* var. *umbonata* MacG., but in that there are only occasionally the long bifid avicularia on the zoecia bordering on the fenestræ, and they must be separated because, among other reasons, the branches have more zoecia in *R. umbonata*; the more delicate *hirsuta* is a tropical form, whereas *umbonata* is Australian.

The *monilifera* group of *Retepora* seems to be well defined, and perhaps should have generic value given to it. All have the well known "trifoliate stigma" on the ovicell, and in most there is a minute avicularium on the lip to one side; the opercula generally are fairly similar with a nearly straight proximal edge, and in shape rather wider than long, with the muscular attachments rather high up and near the border. In *R. formosa* MacG. and *R. contortuplicata* B., the operculum is more curved on the proximal edge, and no labial avicularia have been found in these; apparently all have the labial pore, which is often the end of a long tube opening into the zoecium\* proximally to the operculum, and I agree with Jullien and Calvet in speaking of this as the Reteporidan pore, as it is characteristic of a large number of *Reteporæ*.

There is another group with widely open ovicells, and in these none have a labial avicularium, unless *R. incrustata* Calv. belongs here; the proximal edge of the operculum is not straight, and in some it is contracted in the middle like the opercula of some *Lepralia* (for example *L. hippopus* Sm.). In this group are *R. imperati* B., *R. elongata* Smitt, *R. tessellata* Hincks, *R. solandaria* Risso, *R. inordinata* Calv., having a broad thickened border; while *R. sinuosa* Kirkp., *R. novæzelandiæ* Waters, *R. hippocrepis* Waters, *R. gelida* Waters, *R. lepralioides* Waters, have long bands at the sides of the operculum, for the muscular attachments, and lateral contraction of the oral aperture. The Reteporidan pore has only been observed in this group in *R. solandaria* Risso.

Another group has a fissure in the ovicell as in *R. cellulosa* L. and the proximal edge of the operculum is nearly straight, and very similar throughout this group, labial avicularia occur in some but not in all. There are a few *Reteporæ* with imperforate ovicells. Throughout the genus the oral glands are very well developed.

The minute round or oval avicularia with thin membranous

\* Waters, "Medit. & New Zeal. Reteporidae," Journ. Linn. Soc., Zool. vol. xxv. pp. 255-6; Expéd. Antarct. Belge, pl. vi. fig. 6a (1904).

mandibles occur very frequently in the genus and may be called *Reteporidan* avicularia. There are other small avicularia with solid chitinous semicircular mandibles like those near the oral aperture. These have two muscular tendons, whereas the large triangular ones have a single tendon, and this muscular distinction between the round and triangular mandibles is very frequent in the Cheilostomata.

In the *monilifera* group the growth of the ovicell can be well followed. Looking down the peristome the opening of a large pore is seen in the distal wall (Pl. LXXII. fig. 1) until the ovicell commences to grow (figs. 1 & 2), when the pore is more or less hidden by a disk growing on a small stalk (fig. 2). This disk becomes concave as it grows, showing this to be the commencement of the inner wall of the ovicell (fig. 3), then in a later stage part of the front is open (fig. 5), next the slit of the upper part of the trifoliate stigma is seen (fig. 6), and soon the ovicell is complete (fig. 7).

More or less similar commencements of the ovicell occur in other genera, and sometimes specimens show these disks when no ovicells are developed.

There is one large rosette-plate at the distal end of the zoecium, and the muscles for withdrawing the polypide are arranged on each side of this with a chitinous thickening to which they are attached.

The avicularia are very variable in *Retepora*, and we must not trust to them too much in determining species.

*Loc.* Off Cape York, 8 fath. (*Busk*): Red Sea (*Waters*). Wasin, Brit. East Africa, 10 fath. (500), 20 fath. (520), collected by Crossland.

*RETEPORA PRODUCTA* Busk. (Pl. LXXII. figs. 9, 10.)

*Retepora producta* Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 108, pl. xxv. fig. 7 (1884); MacGillivray, "Tert. Polyzoa of Victoria," Trans. Roy. Soc. of Victoria, vol. iv. p. 115 (1895); Thornely, Records of Indian Museum, vol. i. pt. 3, no. 13, p. 193 (1907).

*Retepora porcellana*, var. *lava* MacGillivray, Prod. Nat. Hist. Victoria, dec. x. p. 15, pl. 95. fig. 6 (1885).

The small semicircular avicularia are very much raised, which is not usual in *Retepora*, and are crenulate, as is frequently the case in the round avicularia of the genus. These avicularia do not occur on the younger zoecia but are common on the others. The zoecia are much smaller than those of *R. porcellana* MacG. and the spines are ridged, but I am not sure that it is right to speak of them as articulated. In the zoecia near the border there are often triangular avicularia with a single beak. The ovicells in the Wasin specimens are not very much raised and have a distinct median slit. On the dorsal surface there are long narrow avicularia; the meshes are large, but "papillary eminences" are not found as a frequent character.

*Loc.* Tongatabu (Polynesia), 18 fath. (*Chall.*); Samboangan, 10 fath. (*Chall.*); Port Phillip Heads, Victoria (*MacG.*); San Pedro Shoal, 25 fath.; Daros Island, Amirante Group (in my collection, sent to me under another name). Wasin, Brit. East Africa, 10 fath. (507), 20 fath. (520), collected by Crossland.

*Fossil.* Victoria, Tertiaries (*MacG.*).

RETEPORA DENTICULATA Busk. (Pl. LXXII. fig. 8.)

*Retepora denticulata* Busk, Zool. Chall. Exp. vol. x. p. 109, pl. xxvi. fig. 1 (1884); Philipps, "Rep. on Polyzoa," Willey's Zool. Results, p. iv. p. 449, pl. xliii. fig. 13 (1899); Calvet, "Bry. d'Amboine," Rev. Suisse de Zool. vol. xiv. p. 620, pl. xxi. figs. 2-9 (1906); Thornely, "Mar. Poly. of the Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 147 (1912).

The lamina of the ovicell is not quite so long as that figured by Calvet, nor has it the orifice mentioned by him. Only a few ovicells have been found. The trabeculae are not barren. There are large bifid avicularia on many of the zoecia near to the distal end, which are probably only the small labial avicularia modified; also there are small semicircular or oval avicularia in the older zoecia, near the middle of the front surface, but in the younger zoecia they are wanting. Similar avicularia also occur in the 'Challenger' specimens.

There are about 11 tentacles.

Internally, at the proximal end on each side of the zoecium, there is a chitinous thickening (fig. 8) for the attachment of the muscles which withdraw the polypide, and between these two sets of retractors there is a thick funicular bundle passing to the next older zoecium. The interior wall of the zoecium is lined with very large square cells, and very similar cells line the zoecial and vibracular chambers and the tube-pores of some *Cupularia*, recent and fossil.

*Reteporella dendroides* Ortmann is similar in many respects.

*Loc.* Sandwich Is., 20-40 fath. (*Calvet*); Lifu, Loyalty Is. (*Ph.*); Amboina (*Calvet*); Amirante, 15-35 faths., Seychelles, 34 fath. (*Th.*). Wasin, Brit. East Africa, 10 fath. (501), collected by Crossland.

RETEPORA JERMANENSIS Waters.

Waters, "Mar. Biol. of the Sudanese Red Sea," Journ. Linn. Soc., Zool. vol. xxxi. p. 176, pl. xviii. figs. 11-16.

*Loc.* Red Sea (*Waters*). Prison Island, Zanzibar Channel (513), the shore, collected by Crossland.

RETEPORA TUBULATA Busk, var.

*Retepora tubulata*, type, Busk, Zool. Chall. Rep. vol. x. pl. xxx. p. 121, pl. xxviii. fig. 2 (1884); Thornely, "Ceylon Pearl-Oyster Fisheries," vol. iv. p. 125 (1905); Records of Indian Museum, vol. i. p. 193 (1907).

The furcate avicularium at the proximal end of the fenestra is not so large or as much divided as in the 'Challenger' specimen, but this divided avicularium is a character of much use in distinguishing the species from *R. hirsuta* B. and some others about the same size with various zoarial characters similar. There are no other large avicularia on the fenestral border, and there is a delicate spine at each side of the oral aperture. As Miss Thornely found in the specimen from the Indian Ocean, the growth sometimes brings the celluliferous surface to the outside as in *R. philippensis* B.

Ortmann has described a species as *R. axillaris* which has an avicularium at the proximal end of the fenestra, but the shape of the avicularium and mandibles differs from the species from Zanzibar in which the avicularia are similar in shape to those of *R. hirsuta*.

There are 11 tentacles, and the oral glands are moderately large but not much elongated.

*Loc.* Cape York, 8 fath. (Busk); Gulf of Manaar (Th.); Gaspar Straits, Malacca Straits (Th.), var. Wasin, Brit. East Africa, 10 fath. (501), Ras Osowamembe, Zanzibar Channel, 10 fath. (501), 10-20 fath. (504, 514), collected by Crossland.

? BIFAXARIA VAGANS Thornely. (Pl. LXV. figs. 13, 14.)

Thornely, "Mar. Polyzoa of the Indian Ocean," Trans. Linn. Soc., Zool. vol. xv. p. 145, pl. viii. fig. 7 (1912).

Zoarium erect, cylindrical, about 0.3-0.4 mm. in diameter, branches dividing dichotomously at nearly right-angles, continuous in the younger portions, but in the older the junctions are broken across and there is a chitinous tube inside the articulation. Zoecia face opposite all round the stem in four directions; the surface of the zoecia has longitudinal ridges and large pits. The secondary orifice is round with a small mucro bearing a small avicularium, with an acute triangular mandible extending into it, while the primary orifice, which is some distance down the peristome, has the proximal edge straight. There are no ovicells on the specimens examined, which were growing on *Retepora*, nor were any ovaria or testes found in the sections made. There does not appear to be any bar to the avicularium. There are about 16 tentacles.

This is much like the 'Challenger' *Bifaxaria reticulata*\* Busk, but in the British Museum specimens there are no avicularia, and the surface is reticulate and apparently not perforate.

*Bifaxaria* of the 'Challenger' is not a satisfactory genus, and will be broken up. It might be retained for *B. submucronata* B. and *B. corrugata* B., which are closely allied, and have the avicularia at the proximal end of the zoecia, not at the distal end as supposed by Busk. *B. denticulata* B. has been removed

\* Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 82 (1884).

to *Sclerodomus* by Levinsen; *B. papillata* B. should perhaps be put to *Urceolipora*; *B. abyssicola* B. probably belongs to the *Cellarinella* group; *B. laevis* B. must be placed elsewhere; *B. minuta* B. perhaps belongs to the *B. reticulata* B., *B. vagans* Thornely, group.

*Loc.* Seychelles, 34-39 fath., Amirante, 34 fath. (*Thornely*). Wasin, Brit. East Africa (500); Ras Osowamembe, Zanzibar Channel (504), collected by Crossland.

#### ADEONIDÆ.

In a short paper in the Annals and Mag. of Nat. Hist. for May 1912\*, I have given grounds for believing that the Adeonidæ will be found to be a much more important group than has generally been supposed, and this in spite of none of the characters upon which it was founded being of the importance then supposed. A large number of the species are pigmented, most have long pore-tubes, there are triangular avicularia on the front, and often vicarious avicularia on the zoarial border, and both kinds are without any cross-bar. There are no external ovicells, the embryos being developed in an ovicellular sac which about half, or, in some cases, nearly wholly fills up the zoecium; and in a considerable number the zoecium in which the embryo is developed is larger than the others, with a differently shaped aperture, together with a difference in the frontal pores, and these larger zoecia have been called gonæcia. The number of species, however, in which there is no difference in the ovicelligerous zoecia is very large, perhaps as many are indistinguishable as are externally recognizable. There are no oral glands in any species examined. I had previously shown that in the *Adeonella* of Busk's 'Challenger' Report there were species in which the pore entered into the zoecial chamber, while in others the pore is above the operculum, also that the opercula in some are nearly straight on the proximal border, others have a broad curve. At the time there was not sufficient material for complete generalisation, but it is now clear that I was right in separating from *Adeonella* species with a pore entering into the zoecial chamber, and it is now seen that they also have a more or less straight edge to the operculum. This group is now known as *Adeonellopsis* of MacGillivray; and *Adeonella*, much the same as I restricted it, is accepted.

The wall of the sac (Pl. LXXIII. figs. 3, 5, s.) containing the embryo (figs. 3, 5, *emb.*) is much thicker than that of the sac in such species as *Lepralia cucullata* B., which also has no external ovicells. The very earliest stages of this sac have not been seen, and while it does not ever seem to hang from the opercular region as a small pendant, yet a comparison with the sacs of

\* Ser. 8, vol. ix. p. 493 (1912).

*Diplodidymia complicata* Rss. (text-fig. 79, p. 491) may throw some light upon the growth.

Blind cells, that is cells without an oral aperture, are very frequent throughout the family, and sometimes the central or stalk portion is composed of such cells. A few have a closure somewhat like those of the Cyclostomata, but not entirely so, as a membrane from below the operculum spreads to the front to make the funnel-like closure. Membranous closures are also occasionally found, and these may be perforated. These closures with tubuli occur in *Adeonella contorta* Mich., and I have found them in *Lepralia syringopora* Rss., one of the Adeonidæ.

The gonocia in Adeonidæ, when distinguishable, frequently are situated near the border, but in one species they are all situated on the median line, while in another they are in groups in various places, distinguishable by the naked eye.

In my recent paper dealing with Adeonidæ I alluded (p. 496) to the ocluser muscles being, as a rule, single in triangular mandibles, whereas the semicircular mandibles usually have two tendons. A slightly different statement would have been better, as I was aware of some exceptions, and since writing I have come upon more—in fact in *Cellepora* and *Holoporella* many of the triangular mandibles have two tendons, but in *Flustra*, *Membranipora*, *Retepora*, and *Cribrilina*, etc., and in most genera the rule seems to be, only one tendon to the triangular mandibles. Some of the exceptions may be in semicircular avicularia modified into triangular ones. I have not got a record on this point of all the mandibles prepared, and must make further examination.

ADEONELLA PLATALEA Busk. (Pl. LXXIII. figs. 3–5, 8 & text-fig. 82.)

*Eschara platealea* Busk, Brit. Mus. Cat. Mar. Pol. p. 90, pl. cv. figs. 1, 2 3, pl. cviii. fig. 4 (*vide* Busk) (1854); MacGillivray, Prod. Zool. Vict. dec. v. p. 41, pl. xlviii. fig. 4 (1880).

*Eschara hexagonalis* Haswell, Proc. Linn. Soc. N. S. Wales, vol. v. p. 41, pl. iii. figs. 1, 2 (1881).

*Adeonella platealea* Busk, Zool. Chall. Rep. vol. x. pt. xxx. p. 184, pl. xxi. figs. 4, 4 a & fig. 50 (1884); Meissner, M., "Liste der von Herrn Prof. Semon bei Amboina und Thursday Island gesammelten Bryozoen," Jenaische Denk. vol. viii. p. 731 (1902); Waters, "A Structure in *Adeonella* (*Laminopora*) *contorta* Mich.," Ann. Mag. Nat. Hist. ser. 8, vol. ix. p. 489 (1912).

*Escharinella cecilleana* d'Orb. Pal. Franç. vol. v. p. 207 (1850); and see Waters, Ann. Mag. Nat. Hist. ser. 7, vol. xv. p. 5 (1905).

I have not had the opportunity of re-examining the *E. cecilleana* d'Orb. since this collection was taken in hand, but the name *cecilleana* cannot be retained, as the description was insufficient.

The ovicellular sac (fig. 3) is formed near the distal end and ultimately fills up nearly the whole of the zoecium, but

the very earliest stage has not been seen. The wall of the sac is formed of short cells and at one part touches the embryo. The embryo in early stages (fig. 5) is surrounded by large and long cells, and in some cases is filled up by formative tissue. In later stages, when the embryo is nearly ready for a free existence the large cells of the calotte are readily followed (fig. 6).

Text-fig. 82.



Lateral surface of *Adeonella platulea*.  $\times 25$ .

When the ovicellular sac has grown to a moderate size there may be, near to the opercular wall, an ordinary polypide, but often there is only a very small one looking like a simple bud, being sometimes not more than a straight tube. There are strong muscles at the distal end on one side for contracting the walls of the ovicellular sac, to which they are attached, as well as to the distal wall. The ovicells of *A. polystomella* Rss., are smaller than those of the other species, but there is the same thick-walled ovicellular sac. Also, in a specimen of *Beania magellanica* B., from Chatham Islands, there is a large embryo in a thick-walled cellular sac nearly filling the zoecium. This I do not find in any of my specimens from Naples, but there is a pair of sac-like bodies near the distal end, and in the Antarctic specimens these bodies are large and were thought to be for the formation of testes, although there are ordinary testes near the distal end in which the spermatozoa can easily be seen.

It has been supposed that all the large zoecia of the Adeonidae, namely the gonocœcia, are merely for embryos, but this is by no means certain, as some may be for the testes, with which some are nearly filled, but the material available does not permit of my saying much on this point. However, it is only in a limited number of species that there are large zoecia, and the same changes may take place in these as in ordinary zoecia; for as the gonocœcia



contain polypides and buds, the embryos are only a stage in the life of the gonœcia.

In the present species the two outer rows of zoœcia are, in parts of the colony, larger than the rest, forming gonœcia with a larger and wider oral aperture, also the pore below it is wider, and a short tongue from the distal end sometimes divides the pore into two. In many species of the Adeonida where there are gonœcia they occur at the border of the zoarium or near a bifurcation, but apparently in no species are they continuous all along the border. When the zoœcia are blind or closed there is often a disc with a central tubule in about the position of the oral aperture.

In *A. platatea* there are at the border of the zoarium, besides the large avicularia, very minute ones between the two zoœcia, and sometimes the small chamber has a round opening and no mandible.

*Loc.* Bass's Straits; Cape Capricorn; Victoria, Queensland (*MacG.*); Port Darwin (*Brit. Mus. Coll.*); China Seas, 82-102 fath. (*Chall.*); Thursday Island (*Meissner*); Ye, Burmah Coast (*Thornely*); Basilan, Indian Ocean (*d'Orb.*). Wasin, Brit. E. Africa, 10 fath. (501, 520); Ras Osowamembe, Zanzibar Channel, 10 fath. (504); Prison Island, Zanzibar Channel, 8 fath. (505): collected by Crossland.

ADEONELLOPSIS CROSSLANDI, sp. n. (Pl. LXXIII. figs. 1, 2, 6, 7, 12-14.)

This is, in many respects, like *A. subsulcata* Smitt, but there seems sufficient reason for separation, for the ridge surrounding the area in *subsulcata* is here wanting and the suboral avicularium is directed laterally.

The zoarium consists of flat branches (a little over 1 mm. wide and less than 1 mm. thick) frequently bifurcating and sometimes anastomosing.

All the zoœcia are about the same size, no difference being discoverable externally in the ovicelligerous zoœcia, although in sections zoœcia nearly filled by the embryo are found occurring indifferently in any position except in the outer zoœcia. The proximal border of the aperture is crenulate and this, as mentioned by Miss Thornely, is the case in *subsulcata*; also the broad median pore is denticulate; however, in some zoœcia, especially those next to the outer row, there is no apparent pore.

There is a small triangular avicularium immediately below or within the aperture, and often a few of the zoœcia near a bifurcation, and some of the bordering zoœcia have also an avicularium at the proximal edge.

The zoœcia at the sides of the zoarium are opposite as, in fact, are all the zoœcia, so that the oral apertures on both sides rise to the same height. On the side of the zoarium there are no vicarious avicularia, whereas they occur in *A. distoma*, *A. subsulcata*, and *A. imperforata*.

The tentacular sheath is attached to the operculum close to its border, and on the inner side of the opercular region there is a small globular body (fig. 2), immediately below which the new bud grows. We see the same thing in various species, among others, in ? *Bifaxaria vagans* Thorn., *A. polystomella* Rss., etc., and it is very large in *Adeona foliacea* var. *fascialis* Kirchenpauer, being about 0.4 mm. in diameter, which is about double the diameter of the globe in the present species. The wall is thick and it may give support to the new bud.

There are about 13-14 tentacles. *A. distoma* has 14-16.

It would seem that the ovicellular zoecia very frequently occur near to a bifurcation, and there may be a group of three or four ovicellular zoecia close together. The few ovaria seen consist of two very small ovarian cells, at first situated at the distal end of the zoecium, but others, no doubt older, occur by the proximal end of the ovicellular sac. The ovaria are similar to those of *Bugula*, and are of about the same size in *Adeonella platalea*, *A. polystomella*\*, and *A. crosslandi*. The early stages of development have not been made out.

The ordinary zoecia may have the polypide entirely surrounded by a testis, in fact, may be practically filled with it.

*Loc.* Wasin, Brit. East Africa, 10 fath. (500, 501), collected by Crossland.

#### EXPLANATION OF THE PLATES.

##### PLATE LXIV.

- Fig. 1. *Aetea anguina* L. Showing the ovicell (*ov.*) at the end of the tubular projection; the retractor muscles (*rm.*) attached just below the tentacles, and also attached at the other end near the commencement of the basal expansion, where the ovaria (*oa.*) also occur.  $\times 85$ . From Wasin (500).
2. Do. do. Front view, showing the operculum and the tentacular sheath (*ts.*) to which the muscles are attached.  $\times 250$ .
3. *Aetea truncata* Landsborough.  $\times 25$ . From Prison Island (505).
4. *Brettia tropica*, sp. n.  $\times 85$ . Dorsal surface. From Wasin (501).
5. Do. do.  $\times 25$ . Anterior surface.
6. *Catenaria diaphana* Busk.  $\times 25$ . From Ras Osowamembe (504).
7. Do. do. Lateral view,  $\times 25$ .
8. Do. do. Operculum,  $\times 85$ .
9. Do. do.  $\times 25$ . Section showing embryos (*l.*) in the ovicell; also an ovum (*ov.*) in the zoecium, and ovaria below the ovicell (*oa.*).
10. Do. do. Ovarium,  $\times 250$ .
11. Do. do.  $\times 85$ . Section of zoecium showing ovicell (*ov.*), diaphragm (*d.*), compensation-sac (*cs.*).
12. *Synnotum pembaensis*, sp. n.  $\times 25$ . From Chaki-Chaki Bay, Pemba Island (517).
13. Do. do. Mandible,  $\times 250$ .
14. Do. do. Avicularium,  $\times 85$ .
15. Do. do.  $\times 3$ .
16. *Synnotum contorta*, sp. n.  $\times 25$ . From Chaki-Chaki (517).
17. Do. do. Avicularium,  $\times 150$ .
18. Do. do. Mandible,  $\times 250$ .

\* *A. polystomella* occurs in the Red Sea, as I find from the examination of a specimen in the British Museum, since my Red Sea paper was written. There is also a specimen from Brisbane (65.5.29.4).

## PLATE LXV.

- Fig. 1. *Vittaticella elegans* Busk.  $\times 25$ . Showing large avicularium. From Prison Island, Zanzibar Channel (503).
2. Do. do. Mandible of large avicularium,  $\times 85$ .
3. Do. do. Small avicularium,  $\times 150$ .
4. Do. do. Distal end, showing the avicularium,  $\times 85$ .
5. Do. do. Showing internodes composed of many zoecia with ovicells,  $\times 15$ . (503).
6. Do. do. Section of embryo in ovicell,  $\times 400$ .
7. Do. do. Section showing zoecia with polypides and ovicells (ov.) in position,  $\times 85$ .
8. *Vittaticella elegans*, var. *zanzibariensis*, nov. Distal end, showing the avicularium,  $\times 85$ . From Wasin, Brit. E. Africa (500).  $\alpha$ , mandible,  $\times 250$ .
9. Do. do. do.  $\times 50$ . Showing small avicularium on the dorsal surface near the distal end.
10. Do. do. do. Upper half of the contents of the vitta,  $\times 250$ . From Prison Island, Zanzibar Channel (505).
11. Do. do. do.  $\times 85$ . Showing internal zoecial muscles. (505.)
12. Do. do. Semidiagrammatic transverse section through the vitta (v.),  $\times$  about 200.
13. ? *Bifaxaria vagans* Thornely.  $\times 25$ . From Wasin (500.)
14. Do. do. Operculum,  $\times 85$ .
15. *Chlidonia cordieri* Aud. Section showing muscles (m.) from the parietal wall to the base of the chamber,  $\times 250$ . From Wasin, Brit. E. Africa (500).
16. Do. do. Operculum,  $\times 250$ .  $\alpha$ , mandible,  $\times 85$ .

## PLATE LXVI.

- Fig. 1. *Stirparia exilis* MacG.  $\times 25$ . Only the lower part of the tuft is shown. From Wasin, Brit. E. Africa (522), 20 fath.
2. Do. do.  $\times 2$ .
3. Do. do.  $\times 85$ . Stem showing disc from which a fresh branch grows.
4. *Stirparia dendrograpta*, sp. n.  $\times 25$ . Only the lower part of the tuft is shown, and for clearness only a few of the spines are drawn full length, but are shown as broken off, which is frequently the case. A pair of radicles are shown growing from the base of a node. From Chuaka, Zanzibar (508), 2 fath.
5. Do. do.  $\times 250$ . Avicularium.
6. Do. do.  $\times 25$ . First zoecium of a tuft, showing long spines.
7. Do. do.  $\times 85$ . Dorsal surface, showing the polypide in the zoecium with ovary (ovar.).
8. Do. do.  $\times 250$ . Ovary from below the polypide, with one ovarian cell.
9. Do. do.  $\times 2$ . On the left a few zoecia are shown in a natural position: the others are spread out as in a mounted slide. This piece is entirely unattached.

## PLATE LXVII.

- Fig. 1. *Cellaria wasinensis*, sp. n.  $\times 25$ . Specimen prepared with Eau de Javelle, showing the openings of the ovicell in an enlarged part of the zoarium. From Wasin.
2. Do. do. Mandible,  $\times 85$ .
3. Do. do. Showing the frontal membrane, with the trabeculae and the tessellated area below the operculum,  $\times 85$ .
4. Do. do. Tessellated area,  $\times 250$ .
5. Do. do. Avicularium prepared with Eau de Javelle, showing the plate in the submandibular part.  $\times 85$ .
6. Do. do.  $\times 3$ .
7. *Cellaria gracilis*, var. *tessellata*, nov. Tessellated area,  $\times 250$ . From Ras Osowamembe.

Figs. 8, 9. *Farcinia oculata* Busk. Stalk growing from stolon,  $\times 25$ .

Fig. 10. *Membranipora armata* Haswell. Opercular region, seen from the interior. The opercular muscle is attached to a linear sclerite (*sc.*) on the membranous operculum, and from the sclerite there is also a muscular band to the tentacular sheath (*ts.*). Two protoplasmic bands (*b.*) pass to the distal rosette-plate.  $\times 50$ .

11. *Diplodidymia complicata* Rss.  $\times 6$ . Colony from Chuaka (506).
12. Do. do.  $\times 25$ . Lower part of colony.
13. Do. do.  $\times 85$ .
14. Do. do.  $\times 250$ . Operculum.
15. Do. do.  $\times 250$ . Mandible.

#### PLATE LXVIII.

Fig. 1. *Stirparia zanzibariensis*, sp. n.  $\times 85$ . From Chuaka, Zanzibar, 3 fath. (506).

2. Do. do.  $\times 2$ .
3. *Scrupocellaria pilosa* Aud.  $\times 85$ . Dorsal surface. From Wasin, Brit. E. Africa, 10 fath. (500).
4. Do. do.  $\times 25$ . Anterior surface.
5. *Scrupocellaria macandrei* Busk.  $\times 85$ . Dorsal surface, showing the groove extending beyond the vibracular chamber. From Prison Island, Zanzibar Channel (505).
6. Do. do.  $\times 85$ . Anterior surface.
7. *Bicellaria chuakensis*, sp. n. Avicularium,  $\times 250$ .
8. Do. do.  $\times 25$ . From Chuaka Bay, Zanzibar Channel, (515).
9. *Scrupocellaria wasinensis*, sp. n.  $\times 25$ . Dorsal surface. From Wasin, Brit. E. Africa, 10 fath. (522).
10. Do. do.  $\times 25$ . Anterior surface.
11. *Scrupocellaria ferox* Busk.  $\times 25$ . Anterior surface. From Prison Island, Zanzibar Channel, 8 fath. (505).
12. Do. do. Mandibles—(a) anterior, (b) lateral,  $\times 85$ .
13. Do. do. Base of vibracular seta,  $\times 250$ .
14. Do. do. Decalcified piece, showing the articulation with the chitinous tube already formed to the inside zoecia of the new branch,  $\times 25$ .
15. Do. do. Dorsal surface,  $\times 25$ .

#### PLATE LXIX.

Fig. 1. *Canda retiformis* Pourt.  $\times 25$ . From Ras Osowamembe, (504).

2. Do. Do. Dorsal surface,  $\times 25$ .
3. *Scrupocellaria cervicornis* Busk.  $\times 25$ . From Wasin (522).
4. Do. do. Dorsal surface, showing the articulation,  $\times 25$ .
5. *Caberea ellisii* Flem. Vibracular chamber seen from the inside: a, b, vibracular chamber; b, c, continuation of the groove beyond the chamber.
6. *Canda retiformis* Pourt. Dorsal surface, to show the articulation.  $\times$  about 6.
7. *Scrupocellaria ferox* B. Do. do.  $\times$  about 6.
8. *Scrupocellaria jolloisii* Aud. Do. do.  $\times$  about 6.
9. *Flabellaris (Menipea) cuspidata* B. Do. do.  $\times$  about 6.
10. *Bugulopsis peachii* Busk. Do. do.  $\times$  about 12.
11. *Menipea patagonica* B. Do. do.  $\times$  about 12.
12. *Menipea buskii* W. Th. Do. do.  $\times$  about 25.
13. ? *Menipea cyathus* W. Th. Do. do.  $\times$  about 25.
14. *Stirparia zanzibariensis*, sp. n. Showing basal stalk from which there are delicate rootlets, and also capsules nearly filled with a bright yellow substance.  $\times 12$ .
15. *Bugula robusta* MacG. Showing the earlier zoecia,  $\times 25$ ; a, natural size. From Wasin (501).
16. do. do. Avicularium,  $\times 85$ .
17. *Scrupocellaria wasinensis*, sp. n. Zoecia showing the position of the ovaria (*ov.*), testes (*t.*), rosette-plates (*r.*).  $\times 85$ .
18. Do. do. Ovarian cells with protoplasmic threads from the rosette-plates,  $\times 250$ .
19. Do. do. Ovaria showing two nucleated ovarian cells,  $\times 250$ .
20. *Scrupocellaria ferox* Busk. Band which starts near the distal end and passes down the side of the zoecium; also small bundle of protoplasmic threads running parallel with the granular band.  $\times 250$ .

## PLATE LXX.

Fig. 1. *Schizoporella nivea* Busk.  $\times 25$ . From Wasin (501). This may perhaps be called var. *wasinensis*.

2. Do. do.  $\times 85$ . Operculum.
3. Do. do.  $\times 85$ . Oral aperture closed by calcareous wall.
4. *Gemellipora protusa* Thornely.  $\times 25$ . From Wasin (520).
5. Do. do.  $\times 85$ . Operculum.
6. Do. do.  $\times 85$ . Interior of the zoecium showing the oral aperture.
7. *Schizoporella nivea* Busk.  $\times 25$ . From Wasin (501).
8. Do. do.  $\times 150$ . Basal avicularium.
9. Do. do.  $\times 150$ . Lateral avicularium.
10. *Petralia chuakensis* Busk.  $\times 25$ . From Chuaka, Zanzibar.
11. Do. do.  $\times 85$ . Operculum.
12. Do. do.  $\times 85$ . Mandible.
13. Do. do.  $\times 250$ . Mandible showing the crenulated border.
14. Do. do.  $\times 25$ . Dorsal surface showing spaces for the attachment of radicle tubes.
15. *Petralia vultur*, var. *armata*, nov.  $\times 85$ . Section through the zoecium, showing the tentacles, with two larger than the others.
16. Do. do. do.  $\times 85$ . Operculum.
17. Do. do. do.  $\times 550$ . Section of tentacles near the base showing the two large fan-shaped tentacles with long nuclei near the edge.
18. Do. do. do.  $\times 25$ . Eau de Javelle preparation. From Chuaka.
19. Do. do. do.  $\times 85$ . Mandible of oral avicularium.
20. Do. do. do.  $\times 85$ . Mandible of round avicularium.
21. *Leprealia feegensis* Busk.  $\times 85$ . Operculum.
22. Do. do.  $\times 85$ . Mandible.

## PLATE LXXI.

Fig. 1. *Membranipora savartii* Aud. Zoecia showing the network of protoplasmic threads. In the upper zoecium histolysis of the polypide has commenced, and in the right hand zoecium (?) histolysis has progressed further, and now considerable granular masses are formed. In the lower zoecium, of which only the distal end is shown, the polypide is in full vigour with digestion active and the tentacles unaltered. Drawn from a decalcified mount,  $\times 85$ . From Zanzibar Channel (528).

2. Do. do. Section showing plasma threads by the side of finely granular cord and parts of narrower cords,  $\times 1000$ .
3. Do. do. The granular masses shown in the right zoecium in fig. 1,  $\times 150$ .
4. Do. do. A similar mass shown in transverse sections surrounded by protoplasmic threads,  $\times 1000$ .
5. ? *Membranipora armata* Haswell. Mandible,  $\times 85$ .
6. Do. do. Decalcified avicularium showing retractor muscle (a), divaricator (b), with tendon attached to the mandible in the middle of the base, and the "peculiar body" (c),  $\times 85$ .
7. Do. do. Avicularium,  $\times 85$ .
8. Do. do. Lower portion of lateral gland,  $\times 320$ .
9. Do. do. Decalcified zoecium showing the avicularian chamber on the left with muscles as in fig. 6, and the glandular chamber (gc.) on the right,  $\times 85$ .
10. Do. do.  $\times 25$ . From Wasin, Brit. East Africa (500).

## PLATE LXXII.

- Fig. 1. *Retepora monilifera*, var. *umbonata* MacG.  $\times 25$ . Showing in the lower zoecia the large pore within the oral aperture, and in the upper zoecia the stalked disc which grows in front of this pore. From Victoria.
2. Do. do.  $\times 85$ . Aperture showing the stalked disc.
3. Do. do.  $\times 50$ . The disc is shown larger and can now be recognised as the commencement of the wall of the ovicell.
4. Do. do.  $\times 50$ . The same rather larger.
5. Do. do.  $\times 50$ . The sides of the ovicell are commencing to grow, but the ovicell is entirely open in front.
6. Do. do.  $\times 50$ . The ovicell showing a large cruciform opening.
7. Do. do.  $\times 50$ . The ovicell shows the complete trifoliate stigma.
8. *Retepora denticulata* Busk.  $\times 250$ . Section of the proximal end of the zoecium showing the muscles (*m.*) attached to the base of the polypide and to the wall of the zoecium, which has a chitinous thickening where the muscle is attached. Between the two sets of muscles a thick funicular cord (*f.*) passes through a large rosette-plate.
9. *Retepora producta* Busk.  $\times 25$ . From Wasin (520).
10. Do. do.  $\times 50$ . Ovicell.
11. *Rhynchozoon profundum*, var. *laminatum* nov. Diagrammatic figure of the aperture and ovicell.
12. *Steganoporella magnilabris* Busk.  $\times$  about 50. Showing the tentacular parts attached to the side wall of the proximal corner, while the stomach, etc., is in the other corner connected by a long narrow oesophageal tube.
13. Do. do.  $\times 50$ . Operculum of B zoecium.
14. Do. do.  $\times 50$ . Decalcified distal end of the zoecium as seen from the front with the polypide seen through the wall and (*sc.*) sclerites to which the frontal muscles are attached.
15. Do. do.  $\times 250$ . Section of the edge of the operculum.
16. Do. do.  $\times 85$ . Section of the distal wall through two rosette-plates. Probably the fleshy parts belong in part to the distal and in part to the proximal wall.
17. Do. do.  $\times 50$ . Section cut through an operculum showing a membrane (*m.*) between the main sclerites.
18. Do. do.  $\times 50$ . Operculum of A zoecium.
19. Do. do.  $\times 85$ . Decalcified distal end seen from inside with the basal wall removed. The tentacular sheath (*t.s.*) is held by four bands (*b.*) attached to the distal wall, also there are muscles (*t.s.m.*) from the distal end of the tentacular sheath to the wall (*a.*) which divides the zoecium. The large retractor muscles (*r.*) are seen attached to a tendon, while below there is a smaller pair of muscles (*d.*) not attached direct to the operculum, but to the frontal wall quite close to the operculum.
20. Do. do.  $\times 25$ . Growing end with the membrane covering the surface. The end zoecia are as yet quite empty and the operculum of a B zoecium (*B.*) is growing, but no basal sclerite is yet formed. In the second row the frontal calcareous wall only extends a slight way into the zoecium and here the zoecium is still quite empty. Next the short tube (*t.*) connecting the two parts of the zoecium grows and the lip commences, but is still some distance from the frontal membrane, though later it rises right up to the proximal edge of the operculum. The frontal sclerite (*sc.*) to which the opesia muscle is attached does not occur in the younger zoecia, but is seen in the mature zoecia.

## PLATE LXXIII.

- Fig. 1. *Adeonellopsis crosslandi*, sp. n.  $\times 250$ . Showing an ovarium in the distal end of the zoëcium. From Wasin.
2. Do. do.  $\times 250$ . Showing round body under the operculum with the protoplasmic threads to the buds below.
3. *Adeonella platalea* Busk.  $\times 150$ . Showing the early stage of the ovicellular sac (s.) near the distal end containing the embryo (emb.). From Wasin (501).
4. Do. do.  $\times 85$ . Section showing the ovicellular zoëcium nearly filled up by the embryo, with an ovarium (ovar.) now proximal to the embryo. From Wasin (501).
5. Do. do.  $\times 150$ . Section of embryo showing the zoëcial wall (z.w.), the ovicellular sac (s.), and the embryo (emb.). The muscles are seen at the distal end on the right in the zoëcial chamber. From Wasin (501).
6. *Adeonellopsis crosslandi*, sp. n.  $\times 250$ . Thick section of embryo showing the aboral end. Fig. 6a,  $\times 250$ . Diagrammatic outline of vertical section.
7. Do. do.  $\times 85$ . Operculum.
8. *Adeonella platalea* Busk.  $\times 85$ . Operculum.
9. *Osthimosia zanzibariensis*, sp. n.  $\times 85$ . Operculum.
10. *Lepralia turrita* Sm.  $\times 85$ . Operculum.
11. *Holoporella albirostris* Sm.  $\times 85$ . Polypide showing the long oral glands.
12. *Adeonellopsis crosslandi*, sp. n.  $\times 25$ .
13. Do. do.  $\times 50$ . Transverse decalcified section showing the opposite zoëcia at about the same stage of development.
14. Do. do. Natural size.
15. *Osthimosia zanzibariensis*, sp. n.  $\times 50$ .
16. *Schizoporella nivea* Busk.  $\times 50$ . The two zoëcia figured were near together but not in the same row, and are placed together to save space. A sac-like structure (sc.) is shown at the base of each ovicell (oc.), but of the numerous muscles in this sac only about half of those in focus are drawn. It seems that the ovum (ov.) passes into this sac which is then ruptured (r.), and the ovum is pressed forward into the ovicell where it segments. The small oral glands are shown (gl.).

35. Notes on Albinism in the Common Reedbuck (*Cervicapra arundinum*), and on the Habits and Geographical Distribution of Sharpe's Steenbuck (*Raphiceros sharpei*). By Major J. STEVENSON-HAMILTON, C.M.Z.S., Game-Warden of the Transvaal.

[Received April 8, 1913 : Read April 22, 1913.]

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*Albinism in the Common Reedbuck (Cervicapra arundinum).*

During the early weeks of 1911 a rumour reached me of three white Reedbucks having been seen near the south-western border of the Sabi Game Reserve. I gave orders that they should be

kept under observation so far as possible, though the very broken and hilly nature of that area rendered any close following of their movements impracticable.

A month or two later a troop of hunting dogs (*Lycan pictus*) passed through that part of the country and, it is believed, killed one of the animals, as only two were afterwards seen. I then made preparations for an expedition to capture the survivors, if possible, for the Pretoria Zoological Gardens, but almost immediately afterwards heard that they had wandered out of the Game Reserve and that the male had been shot by some unknown person. Towards the end of 1911, the last survivor, a female, came back to the Reserve. The Museum authorities having expressed a desire to obtain the skin, failing success in capturing the animal alive, I proceeded to the ground. Under the circumstances it seemed that the capture would be very difficult, and that failure would almost certainly drive the animal out of the Reserve, where it would be killed at once by natives or white men, and so be irretrievably lost. I therefore shot it, and sent the skin, bones, and measurements to the Pretoria Museum, where it is now set up.

The animal proved to be a female about two years old, and of a perfectly pure white colour throughout. The muzzle and inside of the ears, membrane round the eyes, etc., were pinkish or flesh-colour.

The skin on the back of the ears was scabby and unhealthy-looking. Eyelashes white. Pupils reddish black. Inner irides grey blue. Outer irides pearly with darker rays. White of eyes normal. Hoofs and lateral hoofs pale horn colour, the former nearly white at bases.

Measurements for a two year old animal about normal.

Head and body 52 inches; tail  $7\frac{1}{2}$ ; fore girth 32.

When found she was running with an ordinary ram, and contained a perfectly formed male fetus, which was normal in all respects. I should be inclined to think, in view of the time which had elapsed since the disappearance of the male albino, that she had been impregnated by the normal ram with which she was found; but this is a point I cannot speak on with any certainty.

It is worth recording that within a mile of the spot where I saw this animal, and in the midst of the comparatively small area where these Reedbucks had been born and bred, was a village in which lived an albino male native, his hair nearly white, and his eyes of almost the same curious light grey-blue shade as those of the Reedbuck. Native information states that albino children have been born before in the same village, and that white Reedbucks have also been seen in former years in the district.

Some two months later (January 1912) a report came to hand of another albino Reedbuck at a point 60 or 70 miles north of where the female was secured. This animal was always noticed alone, and was repeatedly seen by passengers by the Selati train.



I sent a ranger up to endeavour to capture it alive, but attempts were unsuccessful, owing to the mesh of our net being too large. It was seen close enough, however, to be recognized as a female, nearly pure white and about one year old. After the unsuccessful attempts to capture her alive, she was noticed at intervals for another month; but before another attempt could be made, she disappeared, probably killed by wild dogs.

These animals, which may have been born in 1909 in the first case and 1910 in the second, were found at a considerable distance north and south of one another, and the incidents almost certainly had no connection whatever, but both occurred within a few miles of or among the foothills of the Drakensberg Mountains, on the western border of the Reserve. In nearly eleven years' careful observation of Reedbucks in the Reserve, these are the only cases of albinism that have been brought to my notice.

*Sharpe's Steenbuck* (*Raphiceros sharpei*).

*Spiti-pite* or *Pitsi-pitsi* of the Thonga tribes of the North-east Transvaal and neighbouring Portuguese East Africa.

*Isigulane* of the Swazis.

*Geographical Distribution.*—The most northerly habitat of the species appears to be British Nyasaland, where it was discovered and recorded by Sir A. Sharpe. Thence it extends down through Mashonaland, possibly hugging the vicinity of the eastern hilly country, to the North-eastern Transvaal. It is there found all along the course of the Lebombo Hills (but never in the Drakensberg Mountains, sixty miles further west) as far as the Crocodile River at Komati Poort. It becomes very numerous between the Limpopo and Letaba Rivers, and is there spread through broken ground to as much as thirty miles from the Lebombo. South of the Olifants it becomes progressively scarcer, and is very rare indeed between the Sabi and Crocodile Rivers. It reappears, however, in Swaziland (Mr. R. T. Coryndon), and is found all along the border of that country and Portuguese East Africa on both sides of the Lebombo. Mr. Coryndon is of the opinion that it occurs also in Northern Zululand—that is to say, as far as the end of the Lebombo Hills.

Whatever be the case in Nyasaland and Mashonaland, in the Transvaal and Swaziland it occurs only in one narrow strip comprising the Lebombo Hills and their immediate surroundings.

No antelope answering to the description seems to be reported from Natal or Northern Pondoland, and in the south of the latter we arrive at the extreme known northern limit of the Grysbeck (*R. melanotis*), at Port St. John's.

The geographical distribution of Sharpe's Steenbuck, therefore, seems to be between  $14^{\circ}$  and  $28^{\circ}$  south latitude, and between about  $31\frac{1}{2}^{\circ}$  and  $33\frac{1}{2}^{\circ}$  east longitude, the line of distribution following more or less the south-westerly trend of the coast, though at some distance from it.

There seems to be a gap of  $4^{\circ}$  of latitude in which no small grizzled antelopes are found between the most southerly habitat of Sharpe's Steenbuck and the most northerly of the Grysbeck ( $32^{\circ}$  south).

*Description.*—The animal found in the North-eastern Transvaal has been described from specimens obtained by Mr. Grant (collector for Mr. Rudd). Females and immature males are, generally speaking, of a brighter red colour than old males. The distribution and profuseness of the white in the coats tends to vary in different specimens, and some show more than others. Individuals display small patches of white hairs here and there on back or sides.

In a half-grown female the dark horseshoe mark on the crown was found to continue backwards in the form of a narrowing dark brown line as far as the centre of the back, where it suddenly broadened and then disappeared. In the same animal the face-markings were much more highly contrasted than in older specimens.

There are four mammae present in the females.

I fancied that I detected a very slight thickening of the tissues at the points where the lateral hoofs are found in other species.

The horns of the males are very short and rather conical in shape. They seldom exceed an inch and a half in length, and I should imagine two inches to be about the maximum length.

Mr. Selous has recorded shooting certain small grizzled animals in the Mashonaland Hills which possessed horns over three inches long, and this seems to point, perhaps, to an interesting variation of the type in that country.

*Habits, etc.*—Sharpe's Steenbuck is found either in patches of thick bush, which may be at a considerable distance from any hilly country, or among the stones and boulders of the lesser ridges of the Lebombo Hills and the thick covert sometimes growing at their bases (North-eastern Transvaal). In no case has it been noticed at any very great distance from water. In the hill-country it especially favours the rough boulders interspersed with rank grass and bushes, crowning the crests of long stony ridges which gradually merge into grassy slopes on either side. Its colour almost exactly matches the red tint of the Lebombo rocks, and consequently, when it chooses to lie close, it is a most difficult creature to see. One or more individuals have a custom of returning to the same spot to deposit their droppings, but the habit is not a constant one. It feeds at night or in the very late evenings and early mornings, and, except on dull days, always lies up for the daylight hours among boulders or long grass. In cloudy weather, especially in spring, when the grass is young and fresh, it may be observed quite late in the day feeding close to one of its refuges, moving slowly about, and lying down at frequent intervals. In the stomachs examined, I have found about half the contents to consist of young grass and the rest of the small leaves of ground-shrubs.

When disturbed while lying up for the day, Sharpe's Steenbuck usually springs up 30 or 40 yards away, and makes off at once. Occasionally, however, when well concealed, it lies very close, and only gets up when approached within a few yards. In no case that I have observed did it ever pause before going, resembling many other small buck and hares in this respect. It always goes at best pace for a considerable distance, squatting again suddenly when it has found suitable covert. Its gait is a scuttling run, and it never bounds like a Steenbuck or a Duiker. Nevertheless, its speed is considerable, and, in the rough country affected, it takes a very good dog to run down an adult of either sex.

It is very solitary in habit, and even when a pair are put out of the same patch of bush, they seem generally to have been lying in different parts of it. Bush and rocks seem to be regarded equally as natural refuges, and in following up individuals I could not discover any preference for one over the other. Even in the heat of the day the shade of a large stone on a hillside, destitute of a blade of grass or a scrap of bush, is sometimes sufficient for the animal's requirements.

Most of the females appear to be in lamb (North-eastern Transvaal) in October and November, and I imagine the bulk of the young to be born in the early or mid summer months, though I should hesitate to affirm that they do not, like many other small buck, breed more or less all the year round.

From observation of appearance and habits in the field it would be impossible to recognize its kinship with the true Steenbuck. In habit it approximates much more closely to the Grysbuck, for which it used often to be mistaken by hunters. The native (Thonga) name is *Spiti-pite* or *Pitsi-pitsi* for Sharpe's Steenbuck, while they call the Steenbuck *Inginana* and the Livingstone Antelope *Inhlengana*.

Mr. R. T. Coryndon, the Resident Commissioner of Swaziland, confirms these observations of the animal's habits in the North-eastern Transvaal as being applicable to what he has himself observed in Swaziland, and gives the Swazi name for it as *Isigulane*, for the Steenbuck *Ingcina*, and for the Livingstone Antelope *Inhlengana*. The Zulus call the common Steenbuck *Iqina*. The natives therefore recognize, judging as they do merely from habits and outward appearance, no affinity between the two species of Steenbuck.

Sharpe's Steenbuck is generally spoken of by Colonists in South Africa as "Grysbuck" or "Grys Steenbuck," and in this Province it received its proper title for the first time in the Game Laws of 1912.

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## EXHIBITIONS AND NOTICES.

April 8, 1913.

SIR JOHN ROSE BRADFORD, K.C.M.G., M.D., D.Sc., F.R.S.,  
Vice-President, in the Chair.

THE SECRETARY read the following report on the additions that had been made to the Society's Menagerie during the month of March, 1913 :—

The number of registered additions to the Society's Menagerie during the month of March last was 133. Of these 45 were acquired by presentation, 58 by purchase, 11 were received on deposit, 6 in exchange, and 13 were born in the Gardens.

The number of departures during the same period, by deaths and removals, was 167.

Amongst the additions special attention may be directed to :—

1 Kandt's Cercopithecus (*Cercopithecus kandti*), from Lake Kivu, new to the Collection, deposited on March 7th.

2 Canadian Porcupines (*Erithizon dorsatus*), from North America, presented by W. O. Danckwerts, Esq., K.C., F.Z.S., on March 19th.

1 Kordofan Giraffe (*Giraffa camelopardalis antiquorum*) ♂, born in the Menagerie on March 13th.

1 Greenland Falcon (*Hierofalco candicans*), captured in Mid-Atlantic, and presented by Lt.-Col. F. B. Drage, R.H.G., and the Hon. John Hubert Ward, C.V.O., on March 30th.

2 Purple Kaleege Pheasants (*Gennæus horsfieldi*), from the Himalayas, presented by the Marquess of Tavistock, F.Z.S., on March 3rd.

2 Keysser's Cassowaries (*Casuarius keysseri*), from German New Guinea, received on deposit in immature plumage last September, but identified as new to the Collection on March 12th.

4 Banded Trichogaster (*Trichogaster fasciatus*), from India, new to the Collection, purchased on March 14th.

1 Central-African Mud-fish (*Protopterus athiopicus*), from Uganda, new to the Collection, presented by C. W. Woodhouse, Esq., on March 1st.

2 Gibbous Scorpions (*Buthus gibbosus*), from Sardis, Asia Minor, new to the Collection, presented by Miss Flora Russell on March 11th.

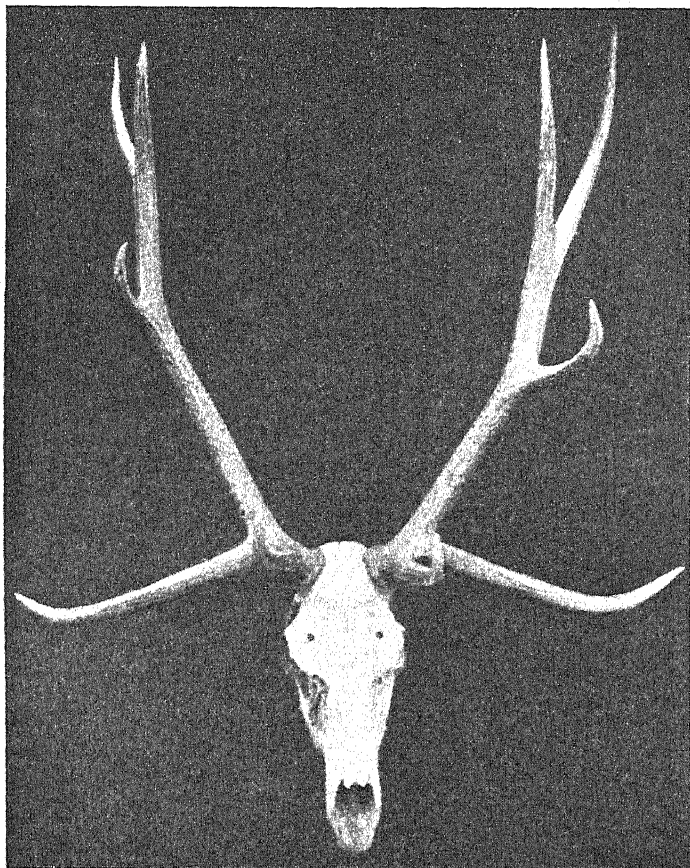
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Mr. H. J. ELWES, F.R.S., F.Z.S., exhibited the head of an Asiatic Wapiti (text-figs. 83 & 84), remarkable for the outward extension of the bay or bez tines, and made the following remarks :—

"The antlers I exhibit were bought in Moscow on my return from Formosa in May 1912 of Mr. Lorenz, who informed me that

they had come direct from the Sayansk Mountains, east of the Upper Yenesei River. The only original account I know of the Deer of this region, though no doubt more recent information exists in Russian, is by Radde in 'Reisen im Süden von Ost-Sibirien,' St. Petersburg 1862, vol. i. p. 284. Radde considered the species to be *C. elaphus*, and says that it was found up to

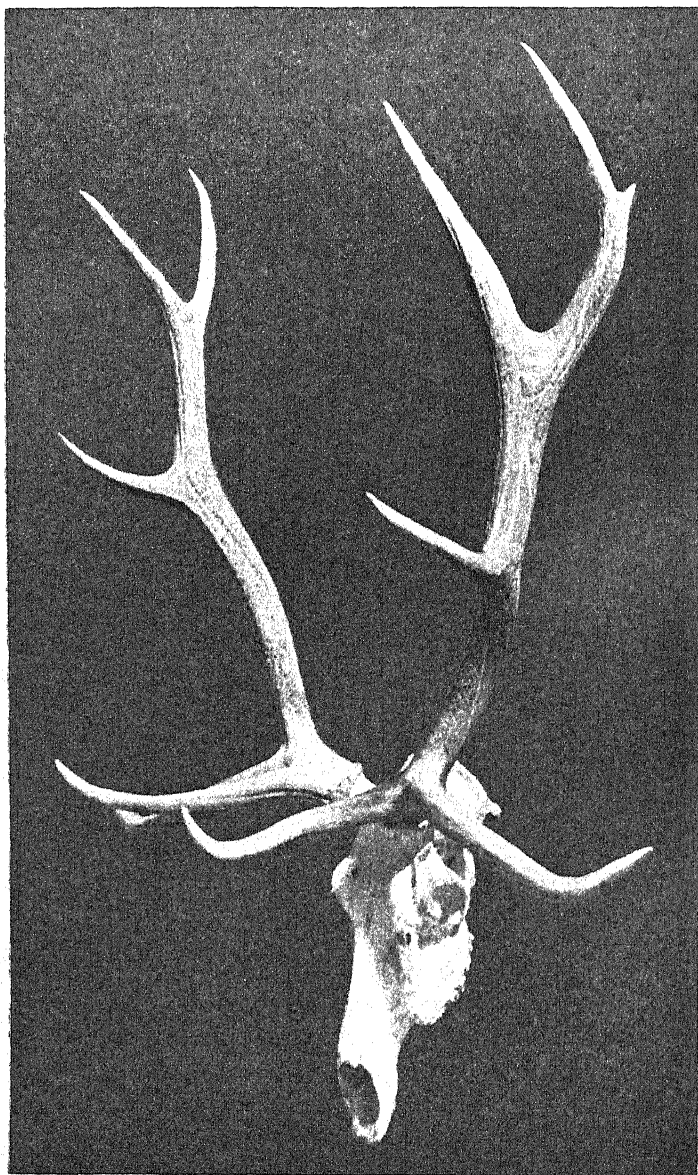
Text-fig. 83.



Front view of antlers of Asiatic Wapiti from the Sayansk Mountains.

and above tree-level on the Sayansk, Baikal, Apfel, and Chingan Mountains, frequenting the thickest forests and islands on the Amur, but wandering in summer as high up as the glacier of Munku-Sardik and over the bare peaks of the Sayansk Mountains.

Text-fig. 84.



Semi-profile view of antlers of Asiatic Wapiti.

"He gives the rutting cry, as imitated by the native hunters with a hollow stem of *Calisace daurica*, as follows, which seems to me to have some resemblance to that of the American Wapiti:—



"In a paper read by me at the Linnean Society on Dec. 15, 1898\*, I spoke of some horns from the Yenesei Valley in the St. Petersburg Museum, which I thought had more resemblance to those of *Cervus elaphus*, having a distinct cup or crown of 6 or 7 tines branching from the same point on the beam, as sometimes seen in old European specimens of *C. elaphus*, but never, so far as I know, in any other Asiatic form of Wapiti. But I have not been able to examine them recently; and the horns shown to-night belong, without doubt, to a race of the Asiatic Wapiti known as *C. eustephanus* Blanford, which name I think preferable to *C. canadensis*, var. *siberica* Severtzoff, though the latter has priority. But until the races of Asiatic Wapiti are better known, I think it is premature to name them definitely, and it cannot be done without careful examination of specimens in the St. Petersburg Museum.

"The bez or bay antlers in my specimen (text-fig. 83) are clearly abnormal in their position. The development of the back tines, though clearly of Wapiti type, is also poor."

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April 22, 1913.

E. T. NEWTON, Esq., F.R.S., in the Chair.

Mr. R. H. BURNE, M.A., F.Z.S., exhibited two pairs of malformed antlers of an Axis Deer (*Cervus axis*), lately presented to the Museum of the Royal College of Surgeons by Capt. Stanley S. Flower, F.Z.S. The deer was born in the Giza Zoological Gardens in 1899, the malformed antlers being shed in 1905 and 1906. The second pair showed a common malformation, *i. e.* duplicity of the brow tine, but the first pair suggested rather an injury during growth than a congenital malformation. At a similar point in each antler the beam was abruptly bent inwards upon itself at a very acute angle. The apical tines also were stunted, probably owing to an interference with the blood-supply brought about by the sharp bend in the beam.

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\* Journ. Linn. Soc., Zool. xxvii. p. 23.

Mr. E. G. BOULENGER, F.Z.S., Curator of Reptiles, exhibited a number of living specimens of the Leaf-Insect (*Phyllium crurifolium*), presented to the Society by Dr. Alfred Russell, which had been reared from eggs laid in captivity, and which showed various stages of development.

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May 6, 1913.

Dr. HENRY WOODWARD, F.R.S., Vice-President,  
in the Chair.

Mr. E. G. BOULENGER, F.Z.S., Curator of Reptiles, exhibited a living melanistic specimen of the Green Lizard (*Lacerta viridis*) recently received from Dalmatia.

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*A new Species of Golden Mole.\**

Dr. R. BROOM, C.M.Z.S., exhibited an example of a new species of Golden Mole from the Transvaal, of which he gave the following account:—

“For a couple of years I have known that a species of Golden Mole occurred near Johannesburg in the Transvaal, but until a few weeks ago the only specimen I had seen was a badly stuffed skin without the skull. Recently I found that two specimens had been ploughed out on the farm Vischkuil, near Springs, and had been skinned by a native. Fortunately the complete carcase of one was still to be had, and most of the skin. On examining the skull I found to my great surprise that the Mole is not a typical *Chrysochloris*, but belongs to the subgenus *Bematiscus*, hitherto only known from Natal and Eastern Cape Colony. The species is a near ally of *Bematiscus villosus* Smith, one of the least known South African forms.

“So few specimens of *B. villosus* are known that we do not at present know the degree of variability of the species, and thus cannot be quite sure whether the few specimens at present placed under that specific name really all belong to one species. The type specimen described by Smith is in the British Museum. It is nearly full grown, and is stated to have come from Natal. The underfur is of very fine texture, and of a slaty-grey colour. The long hairs, which are comparatively few in number, have the outer, flattened portion 10 to 15 mm. in length and of a pale greyish-brown tint, rather darker towards the tips. The fewness of the bristly hairs and their length give the fur a rough harsh feeling.

\* [The complete account of this new species appears here; but since the name and a preliminary diagnosis were published in the ‘Abstract,’ it is distinguished by being underlined.—EDITOR.]



"The skull of Smith's type is well figured by Dobson, and though barely mature is sufficiently near full size for purposes of comparison.

"Dobson described and figured a second specimen which he believed to be *Chrysochloris villosa*, but he recognised differences which he thought might be specific. When working at the Golden Moles some years ago, I thought it well to keep the varieties of *B. villosus* under the one species, though I called attention to the fact of one of the specimens in the Maritzburg Museum having a dark slaty, almost black fur. The specimens are so few in number—there being, so far as I am aware, only five skins in the museums of the world—that one hesitates to split up the Natal supposed *B. villosus* specimens into two species, but it seems likely that when more specimens are obtained at least two subspecies and possibly even species will be recognised.

"Whatever be the case with the Natal specimens, there is no doubt that the present Transvaal specimen is not Smith's *Chrysochloris villosa*, and almost as certainly it is not the same as Dobson's type.

"The Transvaal specimen, for which I propose the name

BEMATISCUS TRANSVAALENSIS,

Abstract P. Z. S. 1913, p. 25 (May 13),

has a thick soft fur very unlike that of Smith's *B. villosus*. The underfur is much shorter and less woolly, and the terminal flattened portion of the hair is less bristly and very much shorter, being only about 7 or 8 mm. in length, instead of 10 to 15 mm. as in *B. villosus*. The terminal portion of the hair is a rich reddish-brown, becoming very dark towards the tip. The whole dorsal side of the animal has thus a reddish-brown tint. On the abdominal surface the reddish tinge has almost disappeared and the fur has a slaty tint. The fur from the sides of the head and nose has been destroyed.

"The claws of the manus of *B. transvaalensis* measure: 1st, 3·7 mm.; 2nd, 16·5; 3rd, 10; 4th, 1·5. The hind foot measures 16 mm., and the length of the body is about 155 mm. The type is a female.

"The skull differs from that of *B. villosus* in a number of characters. The huge crest which rises up from the zygomatic arch is even better developed than in *B. trevelyani*, and a plane laid across the tops of the crests is 2 mm. above the cranial wall. In *B. villosus* the crests pass forwards and outwards, and at a distance of 7 mm. in front of the top of the occiput are 10·5 mm. apart in Smith's type. In Dobson's type they are 10 mm. apart. In *B. transvaalensis* the crest runs forward for some distance nearly parallel, and at a point 7 mm. in front of the occiput are only 6·5 mm. apart. Another important point in the skull is the very much larger temporal bulla. In *B. villosus* the bulla is about 7 mm. in diameter, in *B. transvaalensis* it is 10 mm. in diameter.

"The following skull measurements (in millimetres) indicate the slight differences in size :—

	Length.	Breadth.	Height.	Dental Series.
"Smith's type .....	33	20.5	15.5	13.5
Dobson's specimen.....	34	22	17	13
<i>B. transvaalensis</i> .....	34.5	23.5	17.5	14.5

"The teeth in the specimen of *B. transvaalensis* are in front partly the milk and partly the permanent set. The 1st upper premolar has no internal cusp. The molars are appreciably larger than in *B. villosus*. In *B. villosus* the 2nd molar measures 2 mm. in width; in *B. transvaalensis* it measures 2.5 mm.; and there is an even greater difference in the size of the last molar.

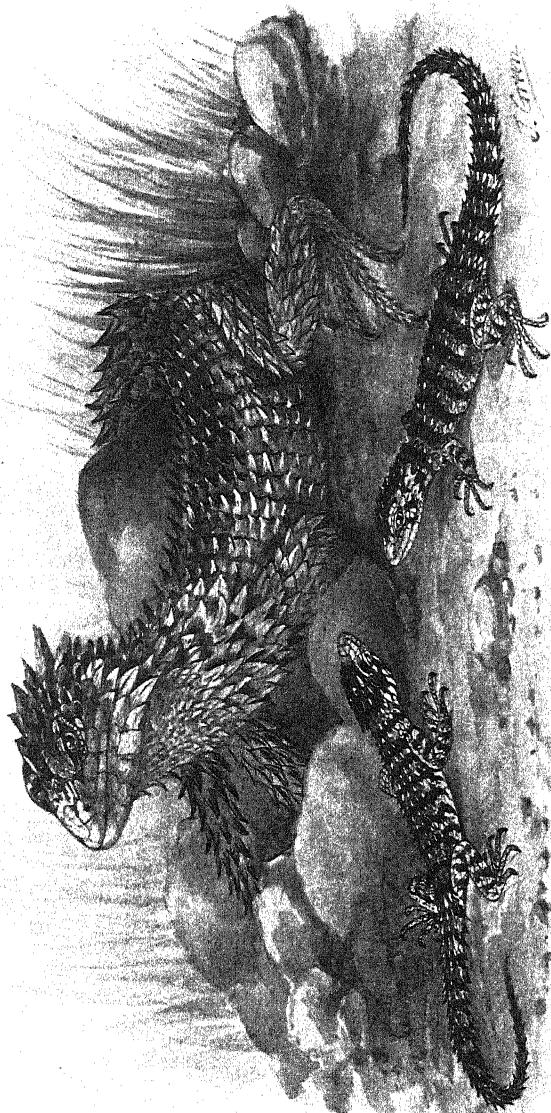
"The type has been deposited in the British Museum."

Dr. BROOM also exhibited an adult female of the large S. African Lizard, *Zonurus giganteus*, with two newly-born young (Pl. LXXIV.), and three adult male specimens of the allied species *Pseudocordylus microlepidotus*.

He gave the following particulars of *Zonurus giganteus* :—

"The mother was given to me by Mr. F. W. Fitzsimons, F.Z.S., of the Port Elizabeth Museum. On opening the box containing the specimen on arrival in London it was found that two young had been born on the voyage. The young differ in appearance very considerably from the mother, being much more brightly coloured. Young specimens in the British Museum collection are described by Mr. G. A. Boulenger as "light yellowish, marbled and cross-banded with blackish brown; the spines not at all developed, and all the scales more strongly imbricate."

"These young also show the marked imbrication of the scales which is largely due to their having no supporting dermal ossification. This gives the tail especially a very different appearance from that of the adult. The colour may be described as yellowish, with, on the back, irregular cross-bands of black. The top of the head is blackish, but in most of the antorbital region the yellowish colour predominates. The scales round the eye are mostly bright yellow, but there is a black spot on the upper eyelid and a less distinct one on the lower. The 4th lower labial has a large black mark, and a black mark extends above this on the upper jaw to the eye. The scales above the tympanum are yellow. On the back the light bands, especially towards the lower half, become very distinctly reddish, and on the tail about half the scales are a light brick-red. The legs are irregularly banded yellow and black, and the front of the body is pale straw-coloured except the neck, which has a number of large black spots. The young measure about 5 inches in length. Mr. E. G. Boulenger assures me that the young are feeding satisfactorily and look lively."



*J. Green, del.*

**ZONURUS GIGANTEUS.**

*Henry Stone & Son, Ltd., Banbury*



## PAPERS.

36. Contributions to the Anatomy and Systematic Arrangement of the Cestoidea. By FRANK E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S., Prosector to the Society.

[Received April 8, 1912: Read May 6, 1913.]

(Text-figures 85-94.)

X. ON TWO SPECIES OF TAPEWORMS FROM *GENETTA DONGOLANA*.

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<i>Dipylidium dongolense</i> , sp. n. ....	549
<i>Diplopylidium</i> , gen. nov. ....	569
<i>D. genetta</i> , sp. n. ....	559

An examination of the small intestine of a Dongolan Genet (*Genetta dongolana*) yielded about a dozen small tapeworms and the hinder part of the body of a larger worm. The latter I have not studied; the former belong to two species which are described in the present paper. Inasmuch as the Genet, which died in November of last year, had been about four years in the Gardens, it is uncertain whether the parasites are to be regarded as indigenous to Africa or had been acquired in captivity. From this particular variety of the Genet I believe that no tapeworms have been recorded; but from allied forms species of Cestodes are known. v. Linstow, in his 'Compendium der Helminthologie,'\* mentions three from "*Viverra genetta*," viz. *Mesocestoides ambiguus* Vaillant †, *Tania platydera* and *T. genetta*, both of Gervais ‡. The latter, as I point out later, may be identical with my *Dipylidium*. *Tania platydera* seems§ to have no rostellar hooks, and may quite possibly be an Anoplocephalid. I refer later to other species from Genets in my description of *Dipylidium dongolense*.

(1) *Dipylidium dongolense*, sp. n.

There were altogether five specimens of this species, all of which I have carefully examined either entire or cut into series of transverse and longitudinal sections. The largest specimen, after preservation in alcohol, measures just 5 mm. in length and 1 mm. in breadth at the broadest part. During life individuals reached a length of 6 mm. The accompanying illustration (text-fig. 85) represents the individual referred to as the largest. The scolex is not sharply marked off from the ensuing neck, which is very short and soon passes into the

\* Hannover, 1878, p. 37.

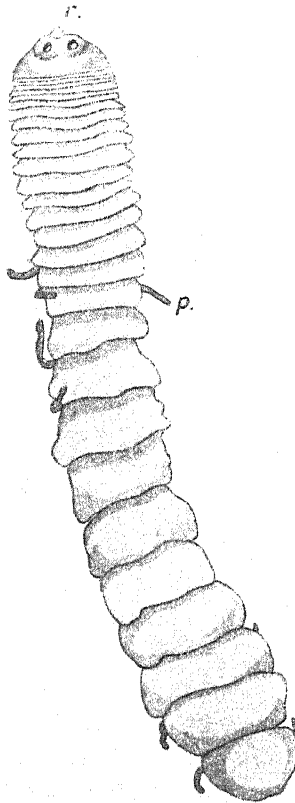
† Comptes Rend. Soc. Biol. Paris, 1863, p. 48.

‡ Mém. Ac. Sci. Montpellier, 1847.

§ Cf. Diesing, Syst. Helminthum, i. p. 519.

strobila. The neck is at once wider than the scolex. The protruded rostellum has several rows of the usual minute thorn-like spines characteristic of the genus *Dipylidium*. The rostellum has a three-pointed appearance, which will be obvious from the drawing, the narrowest part being the apex.

Text-fig. 85.

*Dipylidium dongolense*.

View of entire worm, magnified.

p. Extruded cirrus. r. Rostellum.

I believe that there are four rows of spines upon the rostellum. The four suckers are not very large. The shape of the terminal segment of the body seems to me to prove that the specimen which I here figure is a complete individual with no posterior segments shed. It will be noticed that the proglottids are nowhere longer than broad, and that they overlap laterally. The segmentation of this species is thus very different from that of

the type species of the genus, *Dipylidium caninum*. An inspection of the figure will render a detailed description of the proglottids of the present species unnecessary; it will be noticed that their number is small, not more than 28. In another specimen I only found 22. In this example (or in one very like it) the last nine segments became suddenly very much more elongate, and were three to four times as long as broad. In transverse sections the body shows an elliptical form pointed at the two ends laterally and nearly as deep as wide.

The general structure of the body shows certain differences in the less mature and more mature segments, which do not appear to me to be altogether due to the greater tension in the latter. The specimen which I selected for examination by means of transverse sections was much like that of which I give an entire view in text-fig. 85. But in the posterior segments, though short, the sexual organs were well developed, and there were ripe ova lying in cavities (of which a full description will be given later). In these transverse sections the cuticle is very thick and the layer of subcuticular cells very conspicuous and deeply stained; they have the usual flask-shaped form and lie in a dense layer, being closely adpressed. Their thinner outer ends are in contact with the cuticle above them. Upon this layer follows a layer of lax tissue, and then a strong longitudinal layer of muscular fibres, which are themselves separated from the medulla by a thinner layer of transverse muscular fibres. These fibres are associated together in bundles of three or four fibres, which are very stout; there appear to be also a few fibres to the outside, which are not associated in bundles but implanted singly. In longitudinal sections it is rather easier to count the number of fibres which lie in a single radial row of this longitudinal layer, and I find that there are not more than five or six. Here and there between the bundles are parenchymal cells whose deep staining as contrasted with that of the muscular fibres emphasizes their existence. In sagittal sections the subcuticular layer is also obvious in the more anterior proglottids. I have not been able to get any transverse sections of the more elongated posterior proglottids (owing to the limitation of my material); but in longitudinal (sagittal) sections I could find no trace whatever of elongated flask-shaped subcuticular cells. The general cortical parenchyma reaches absolutely up to the (here) very thin cuticle. There are, I think, only two possible explanations of this appearance of vanished subcuticular cells. First, that they have altered their form owing to the pulling out of the segment, and have become broader and round like the cells which secrete the calcareous bodies; or secondly, that they are really absent from this region of the body. It is clear from the observations of Lönnberg that the subcuticula varies among tapeworms. It is, for example, in *Tetrarhynchus tetrabothrius*\*

\* "Anatomische Studien über Skandinavische Cestoden," K. Svensk. Ak. Handl. xxiv. 1891, pl. i. figs. 6, 11.

a layer two or three cells deep, of which the outer ones are close to the cuticle. On the other hand, in *Ptychobothrium belones* the more scanty subcuticula lies in the parenchyma some way below the cuticle. I find on a re-examination of sections of *Hyracotenia hyracis*\* that the subcuticula occurs in patches on the mature segments, and seems, therefore, to be in course of disappearance. It is, moreover, mentioned by Gough† that in *Stilesia* the subcuticular layer is not to be found in "older portions of the strobila in segments where the paruterine organ is fully developed." Gough holds that this absence of the subcuticula in mature segments is a secondary character. The state of affairs seems to bear out the suggestion that in my *Dipylidium* the subcuticula has actually disappeared in the mature segments.

The testes occupy all the available space in the proglottids, and are thus mainly between and posterior to the ovaries. In the more elongated and riper proglottids the testes are only one row deep and not more than 6-9 (according to the length of the segment) in a single row; they are thus evidently not so numerous as in some species.

The two generative orifices lie one on each side of the body not far from the anterior boundary of the proglottids. The cirrus-sac is in front of the vagina, and, as is shown in sagittal sections, in the same straight line with it, being neither dorsal nor ventral. The cirrus-sac has very definite, rather thick muscular walls, which are even quite obvious when the sac is dilated in mature segments, though not so thick in appearance. The cirrus is long and much coiled within the cirrus-sac. The sperm-duct is also much coiled, and the two sperm-duct coils very nearly come into contact in the middle of the segment.

The ovaries of this *Dipylidium* are, as a rule, clearly two in each proglottid lying rather laterally and anteriorly. They are, in fact, like those of other species, such as *D. zschokkei* of Hungerbühler, as to their position in the proglottid. But I do not find in cases which I have particularly examined that there is an absolutely complete separation between the two ovaries of a given proglottid. In this matter I refer to rather anterior proglottids which are not elongated and stuffed with ripe eggs containing embryos. However, in other proglottids I found a distinct separation between the two ovaries, the fact being that they approach very near to each other in the middle line of the segment. There is, however, no doubt about the entire separation of the vitelline glands, each of which lies behind the ovary of which it is an adjunct. The ovaries occupy a good deal of the space in the short proglottids where they occur when full sized. They are posterior to the coils of the vas deferens, but reach very nearly to the posterior end, where the testes occur; the testes also occupy the available space between them.

The receptaculum seminis penetrates the middle of the ovary

\* For species, see P. Z. S. 1912, p. 593.

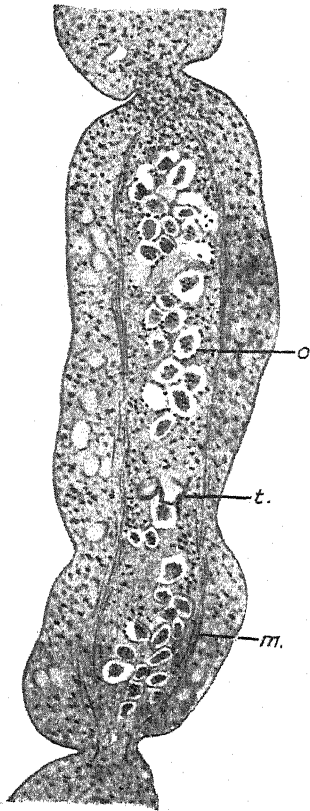
† "A Monograph of the . . . Avitellinae," Q. J. M. S. lvi. 1911, p. 345.



and is greatly swollen so as to be almost spherical in this region. It is several times the diameter of the vagina.

The *uterus* in the genus *Dipylidium* is thus described by Ransom in his definition of the genus\*:—"Uterus at first reticular, later breaking up into egg capsules, each containing one or more

Text-fig. 86.



*Dipylidium dongolense*.

A completely mature proglottid seen in sagittal section.

*m.* Longitudinal muscles. *o.* Ripe embryos, each in a separate cavity.  
*t.* Remains of testes.

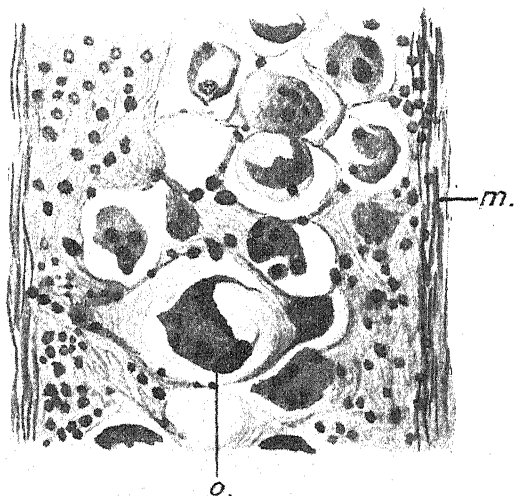
eggs." Nearly the same definition, but not quite so explicit, is given by Fuhrmann †, who writes:—"Der Uterus löst sich in

\* "Cestodes of N. American Birds," Bull. U.S. Nat. Mus. no. 69, 1909.

† "Cestoden der Vögel," Zool. Jahrb. Suppl. vol. x. 1908.

einzelne ein oder mehrere Eier einschliessende Säckchen auf." These definitions are, as I presume, chiefly based upon the many observations made upon the best-known species of the genus, viz. *Dipylidium caninum* (= *Tenia cucumerina*, mult. auct.), of which they are a correct restatement. But Fuhrmann has himself described in an Avian *Dipylidium*\* a series of sinuous uterine tubes preceding a series of egg-capsules each containing a single egg. Furthermore, although he gives no details, Diamare† asserts that the development of the uterus in other species is as in *D. caninum*.

Text-fig. 87.

*Dipylidium dongolense*.

A portion of the section represented in text-fig. 86, more highly magnified to illustrate the absence of a special lining membrane to the egg-holding spaces.

Lettering as in text-fig. 86.

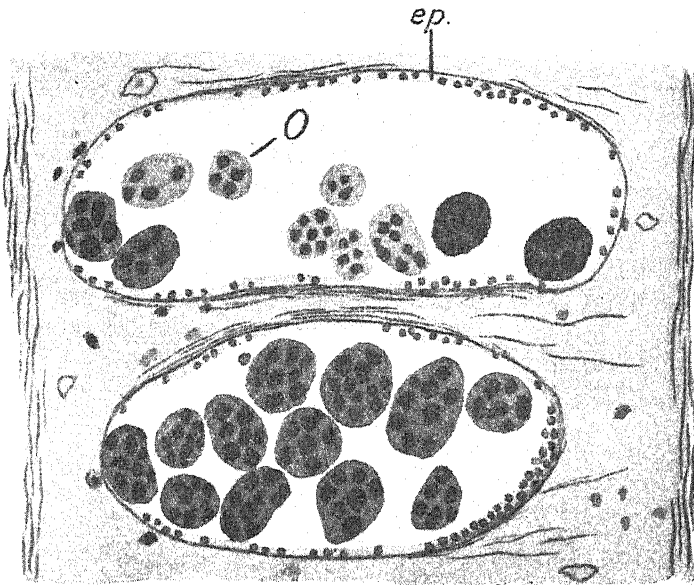
In the species of which the present paper is an account I can find no confirmation of Diamare's statement concerning the development of the uterus, though his figures of the completely mature uterus of *D. trinchesei* and *D. pasqualii* agree very closely with what I have seen in mature proglottids of *D. dongolense* (see text-fig. 86). In the largest specimen which I have been able to examine, in which the last nine proglottids were elongated, it was only the last two which agreed really closely with the figures given by Diamare and just referred to. In these alone the embryos were contained each in its own separate compartment, which it did not by any means fill. I lay particular stress upon the fact that they

\* "Taenien der Raubvögel," CB. Bakt. u. Paras. xli. 1906.

† "Il genere *Dipylidium*," Atti R. Acc. Napoli (2) vi. 1894.

were embryos, since in Diamare's figures they are clearly eggs which have not yet segmented to form embryos. In *Dipylidium caninum* (as I suppose), an example of which I have studied from the Asiatic Jackal, the separate chambers of the mature uterus were very plainly lined with a cellular layer. I may observe of this *Dipylidium* incidentally that the number of embryos in a given chamber was very much greater than what is figured in that species by Diamare, who only represents 3-7. I found quite 30 or more.

Text-fig. 88.



*Dipylidium caninum.*

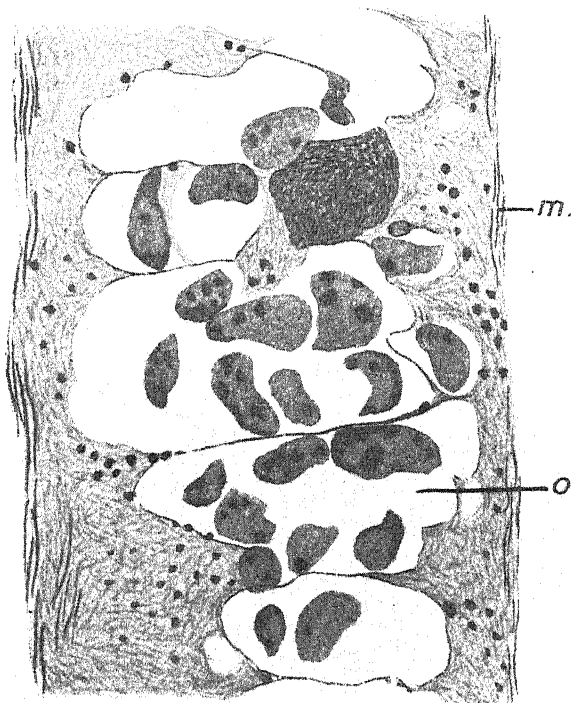
A portion of uterus in a mature proglottid.

ep. Epithelial lining of uterine cavities. O. Embryos.

In *Dipylidium dongolense* there was not, so far as I could see, any special lining membrane to the small chambers which lodged, each of them, a developing embryo. It will be observed in the text-figure (text-fig. 87) which illustrates the mature "uterus" of the present species, that the appearances presented are consistent with the view that the chambers which contain the eggs are merely interstices in the general medullary network. Their walls are perfectly continuous with the medullary tissue lying to the inside of the longitudinal muscles and forming the peripheral layer of the medulla. Though the walls of the cavities often contain imbedded in them crowded nuclei, it must be borne in mind that the peripheral layer of the medulla is also crowded

with quite similar nuclei. Furthermore, the nuclei (see text-fig. 87, p. 554) do not give the impression that they line the cavities; they belong rather to the tissue of the walls: there are, moreover, often considerable tracts without any nuclei at all, as is often the case with the medullary tissue of tapeworms. This is, of course, opposed to the idea of a lining membrane.

Text-fig. 89.

*Dipylidium dongolense.*

A portion of a section through a proglottid less mature than that represented in text-figs. 86 & 87.

*m.* Longitudinal muscles. *o.* Egg-holding spaces.

All this contrasts greatly with the uterine spaces of *D. caninum* (see text-fig. 88, p. 555), where there is invariably a close row of nuclei with accompanying protoplasm actually lining the cavity and in which the nuclei of the medullary tissue are not numerous and, as a rule, different from those of the lining membrane. The medulla, in fact, forms a reticulum in the meshes of which lie the developing embryos; there is not, at any rate in the fully mature stage, any uterus at all. A

consideration of the disposition of the eggs in proglottids anterior to the two that have just been described bears out this view. In the two proglottids anterior to the two terminal ones, the arrangement of the eggs, or rather developing embryos, in the medullary parenchyma was as follows:—The medullary region is not so entirely given up to these eggs as it is in the case of the last two segments that have been described above. In the two latter but slight traces are left of the testes; in the less mature proglottids more testes are found. They have, however, commenced to disappear, for in the proglottids antecedent to these the testes are more abundant and therefore take up more room. The space apparently thus left by the degeneration of the testes is occupied by the developing eggs. It is not, however, a continuous cavity running from end to end of the proglottid (see text-fig. 89). It is divided here and there by delicate trabeculae into compartments, each of which contains a considerable and varying number of developing embryos\*. Further forward still, the embryo-containing spaces are less conspicuous owing to the full development of the testes, which thus occupy more room. I can draw no line of demarcation between these cavities in which lie the developing embryos on the one hand, and spaces which lodge ova and form actually a part of the ovary on the other hand, in the more mature proglottids which have begun to become elongated. As already mentioned in describing the ovary of this species of *Dipylidium*, the ovaries are mature or, at any rate, possess plenty of full-sized ova in proglottids which are not at all elongated and are, indeed, still broader than long. In these proglottids, however, there is no trace that I could find of a definite uterus, and nothing at all like the obvious retiform uterus of not fully mature proglottids of *D. caninum*. However we may interpret the embryo-holding spaces of *D. dongolense*, it is clear that they cannot arise in the same way that the egg-sacs of *D. caninum* arise, i. e., by a breaking up of a continuous retiform uterus into a number of discontinuous sacs.

With what, then, can we compare the spaces which surround the developing ova in this and other species of *Dipylidium*—in fact, possibly in all with the exception of *D. caninum*? I do not think that any genus has been described as possessing an exactly similar mode of lodgment of the developing eggs. But there are nevertheless some comparisons to be made with other forms.

The final stage shown in *Dipylidium dongolense*, where the eggs are uniformly scattered through the medullary region, each in its own separate compartment, is suggestive of *Oochoristica*, with which genus *Dipylidium* is usually considered to be properly associated. The comparison, however, can hardly be exact, since, as we have seen, this final stage is preceded by larger spaces containing each of them many developing embryos. It seems to

\* In one specimen I have also seen ova enclosed by threes and fours in cavities in the cortical layer. But this seems exceptional.

me that we must come to the conclusion that a growth of the medullary parenchyma between the individual eggs produces the final result seen in the terminal and penultimate proglottid of the specimen which I have studied. It might be argued that this process is really comparable to the formation of paruterine organs which are growths of medullary tissue encapsulating the eggs though with histological change. In *Dipylidium* we have no histological change, but all the same encapsulating growths of parenchyma.

Having given an account of the structure of this *Dipylidium*, it remains to be decided whether it be a new species or identical with one of those already described. It is, as I think, hardly necessary to say much of *D. caninum*, with which there can be no possibility of confusing the present species. The much greater size of that species and the form of its uterus at once distinguish it from that which is the subject of our present communication. It seems indeed to me that the genus *Dipylidium* requires really division into two genera—*D. caninum* belonging to one, and all the other species that are adequately known to the other. It is from the latter that it is not so easy to distinguish *D. dongolense* of the present paper. If *D. genettæ* of Gervais\* and *D. gervaisi* of Setti were not much larger species than mine, I should have been inclined to identify it with one or possibly both of them.

*D. echinorhynchoides* (from *Megalotis cerda*) is much larger than my species, has a much longer rostellum and a longer neck. *D. trinchessii* is a smaller species, but still considerably larger than *D. dongolense*, measuring 2.5 cm.; it has, however, a short rostellum, like that of my species; but it is to be distinguished by the greater length of the mature segments, which do not overlap, and the invariable inclusion of each ripe ovum in a separate compartment. Though a receptaculum seminis is said to be present, it is hardly represented in the figure†. *D. pasqualii*, on the other hand, has an obvious receptaculum‡, but it is a much larger species, i.e. 200 mm. The uterus is as in the last, and therefore differs from that of *D. dongolense*; but it is to be noted that the ripe ova extend into the cortical layer, as do the egg-chambers of *D. dongolense*. Occurring as it does in the intestine of a closely allied species, it might be expected that *D. gervaisi* of Setti§ would be more closely allied to *D. dongolense* than the other species of *Dipylidium* referred to. It is not, however, as it would appear, any nearer in structure. For in this species, as in most others, the ripe ova are figured as embedded separately in the parenchyma, without any previous inclusion in larger cavities. It is also rather larger, being from 1-4 cm. in length.

Nor can the present species be confused with *D. zschokkei*||.

\* Mém. Ac. Sci. Montpellier, 1847.

† Diamare, loc. cit. pl. i. fig. 9.

‡ Loc. cit. pl. i. fig. 8.

§ "*Dipylidium gervaisi*," Atti Soc. Lig. Sci. Nat. vi. 1895.

|| Hungerbühler, "Studien au Gyrocotyle und Cestoden," Denkschr. Ges. Jena, xvi. 1910, p. 516.

For the latter reaches a length of 120 mm., and the ripe proglottids may be four times as long as broad. Moreover, the neck of *D. zschokkei* "muss als sehr lang bezeichnet werden." It appears also that my species has a much more pronounced receptaculum, which is mentioned by Hungerbühler as existing in *D. zschokkei*, but is hardly indicated in his figure\*. This species occurs in *Cynictis penicillata*. *Dipylidium triseriale* of Lühe also appears to differ—a species which occurs in the African Civet cat†. For Lühe says of that species that the ripe eggs are imbedded singly in the parenchyma, and makes no mention of previously existing spaces, a state of affairs which I have described in my species. Moreover the genital pores of *D. triseriale* are further back than in my species, and it is larger in size. In *D. triseriale*, moreover, the proglottids are described by Lühe as being "ungefähr quadratisch," which I presume means that they do not overlap as in my species.

A second species, *Dipylidium monoophorum*, is also described by Lühe from the same host, which only measures 10 cm. in length and therefore more nearly approaches the dimensions of *D. dongolense* of the present paper. But in this species, as in *D. triseriale*, the length of the ripe proglottids is much greater; and furthermore, the two separate small round ovaries (with the vagina to the outside of each) are not what I have seen in *D. dongolense*.

Diamare‡ has described, besides the well known *D. caninum*, *D. echinorhynchoides* Sonsino, two species named by himself, viz. *D. trinchesei* and *D. pasqualii* (both from the common cat), and two doubtful species, which are *D. (?) genetæ* Gervais and *D. monticellii*.

### *Diplopylidium genetæ*, gen. et sp. n.

I refer what I believe to be a new species of Tapeworm to the new genus *Diplopylidium* for reasons which I shall discuss after setting forth the structure of this worm. The intestine of the Dongolan Genet contained fewer specimens of this worm than of the *Dipylidium* which has been described above. They were, however, of about the same size, measuring up to 6 mm. or so in length, and consisting of about 28 segments at most.

The accompanying drawing (text-fig. 90) represents an average sized example to which the above statements apply. The scolex is as broad as the body which follows, and there is only a slight increase up to the end of the body. The worm has thus a sturdy form, and is so far much like the *Dipylidium* which has just been described. It agrees with it, moreover, in thickness, the transverse sections being oval in outline and not much flattened from above downwards. The scolex is furnished with an armed rostellum, which is large in contrast to the comparatively small

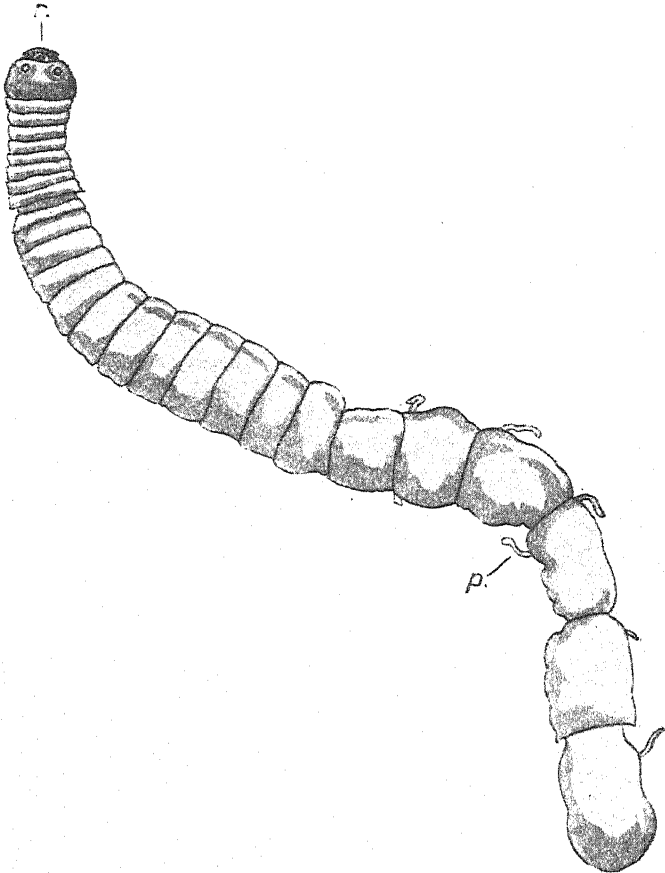
\* *Loc. cit.* pl. xix. fig. 18.

† "Beiträge zur Helminthenfauna des Berberei," SB. Ak. wiss. Berlin, 1898 p. 826.

‡ "Il Genere *Dipylidium*," Atti R. Acc. Napoli (2) vi. 1894.

suckers. These latter are unarmed and show no peculiarities of moment; they face outwards and slightly forwards. The hooks of the rostellum are large and arranged in two rows, 17 to each row. Their shape and relative size can be understood from an inspection of text-figure 91, which represents a longitudinal section

Text-fig. 90.

*Diplopygidium genetæ.*

View of entire worm, magnified.

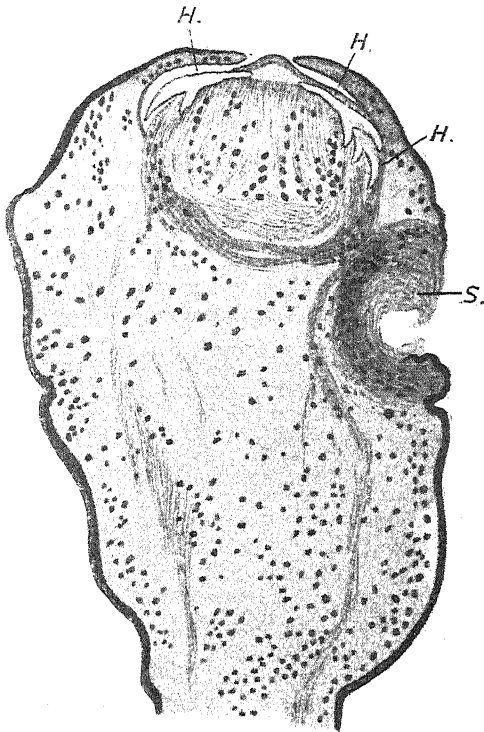
*p.* Extruded cirri. *r.* Rostellum.

through the retracted rostellum of this species. The rostellum is a muscular one, but with fewer external layers of muscles than is sometimes met with, which act as protractors of the rostellar bulb. The stout retractors (see text-fig. 91) are of course continuous



with the longitudinal muscular layer of the body, which is posteriorly not thick but quite evident. In comparing the present species with *Dipylidium dongolense* in the living state, I noted a difference in the dispersion of the calcareous corpuscles. In both species they were abundant throughout the body generally; but in the *Diplopylidium* alone did I succeed in detecting any in the scolex.

Text-fig. 91.

*Diplopylidium genette.*

Longitudinal section through anterior end of body.

H. Hooks on rostellum. S. Sucker.

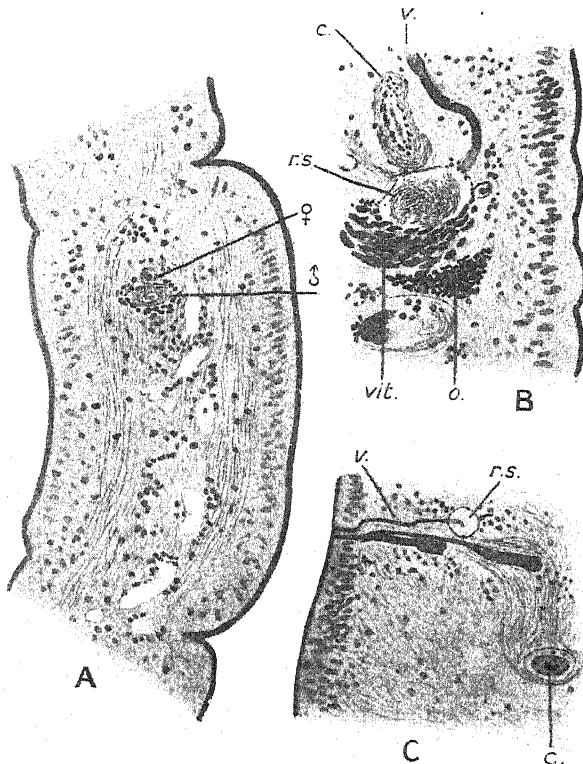
The *testes* of this species are numerous in proportion to the size of the proglottid. They are ripe in the earlier segments, where the ova are not mature, but still attached to the ovaries. In such segments the testes are closely crowded together and fill all the available space of the proglottid from one end to the other. They lie, however, within the ovaries, thus occupying the middle of the proglottid. I counted up to twelve or so in a single longitudinal row. The *cirrus-sac* of

the worm is large and has an obvious and thick muscular coat. A peculiarity about this organ is that it does not lie in a straight line extending inwards from the point of opening on to the exterior, and thus at right angles to the long diameter of the proglottid, as is so usually the case. The sac, on the other hand, often bends at right angles near to its external pore and passes backwards; at other times it is more irregular in its folding. Its large size is responsible for this folding, as the two cirrus-sacs of a given segment would meet in the middle line did they run straight inwards from the external pore. The cirrus itself is a very fine tube upon the end of which I could detect no spines; it is coiled within the cirrus. The sperm-duct after emerging from the cirrus-sac forms a coil which is anterior to the sac and near to the front of the segment.

The *vagina* of this Cestode together with adjacent parts of the genital system is shown in text-fig. 92. The most remarkable fact is that that tube opens anteriorly to the cirrus, a position which is made plain in the text-figure referred to. It would also appear from a study of a series of sagittal sections—which are the best in which to study these particular relationships—that the vagina has not a separate orifice on to the exterior of the body. But the truth of this conclusion will be doubted after an inspection of text-fig. 92. For in that figure the vagina seems to open separately, and of course anteriorly to the cirrus-sac. It may be that this is at times the case; but it is also clear that in tracing the vagina in a series of sagittal sections the tube is lost sight of in the walls of the male duct before the latter reaches the exterior. I believe that among the Tetracotylea the genus *Tetraphothrium* is the only genus in which the female openings are in front of the male. It is true that in the Ichthyotæniidæ generally, if not universally, there is an irregular alternation in these conditions, the female duct lying in one segment in front of and in another behind the male pore. But it is doubtful whether this family is to be safely referred to the Tæniadæ. The figure referred to (text-fig. 92 C) shows the narrow vagina lying in front of and parallel with the stouter cirrus-sac, the two forming in this region a perfectly straight line, so that their relative positions is a matter of ease to ascertain. I found the same relations in other series of sections besides that from which the text-figure referred to has been taken. Thus I am able to state that there is not an alternation in the positions of the male and female openings, as in *Ichthyotænia*. The vagina is darkly stained and of small calibre in this tapeworm, the small bore of the tube bearing a relation to the fineness of the cirrus. Another remarkable circumstance is the nature of the receptaculum seminis and less mature and more mature proglottids. In text-figure 92 C the slender vagina is seen to open into a minute spherical chamber or dilatation and to issue from the opposite side as an equally slender tube. This chamber is, as I suppose, to be compared to a receptaculum seminis; but it has in this section

the appearance of the mere beginning of such a chamber. There is no trace of sperm to be found in it, and it is so small that I have not been able to detect it in other sections of neighbouring segments. The particular section to which attention has been

Text-fig. 92.



Three sections through the generative region of *Diplopylidium genettæ*.

- A. Section to show relations of vagina (♀) and cirrus-sac (♂), the latter lying behind the former.
- B. A transverse section through the receptaculum seminis and adjacent parts of the generative system.  
c. Cirrus-sac. o. Vitelline gland. r.s. Receptaculum seminis. v. Vagina. vit. Ovary.
- C. Transverse section showing immature receptaculum seminis (r.s.) and anterior position of vagina (v.).  
c. Cirrus-sac.

N.B.—There is an appearance of a diverticulum of the cirrus probably due to irregular staining.

called is of a proglottid filled with completely mature eggs, enclosed in their shell, and which have developed into embryos. It is rather remarkable to find that the receptaculum is so small and immature in a section which is otherwise quite ripe. For the receptaculum does not suggest a reservoir from which the contents have been recently expelled; it distinctly suggests an incompletely developed receptaculum. On the other hand, text-figure 92 B is from a section of which the maturity was less advanced. The testes were fully ripe, and the ovaries quite developed; but there were no ova scattered through the parenchyma at all. And if I have missed any in the examination of the section, they must at most have been few. Yet in this section, as will be seen from the drawing cited, the receptaculum seminis is very large and quite distended with abundant sperm. Nor can this difficulty be explained away on the assumption that one of the two vaginae in the fully-ripe proglottid was more mature than the other, and may have been the storehouse of the sperm after copulation. For I ascertained that the vaginae on both sides of the body were in an identical state of maturity.

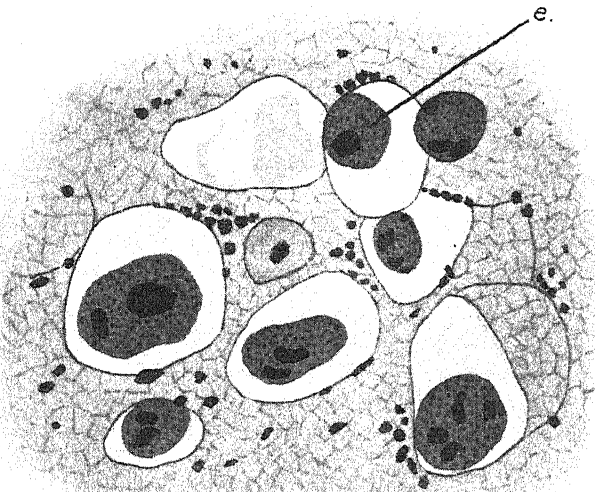
The ovaries in this species are distinctly double, and lie one on each side of the proglottids a little way behind the point of opening of the generative ducts. The ovary is in each case immediately followed by the *vitelline gland*. There seem to be no features of special interest about either the ovaries or the vitelline glands. On the other hand, the *cavities lodging the ripe eggs* are remarkable, and like those of but few other tapeworms that have been described. I do not give to these cavities the name of "uterus," for it does not seem to me to be proved that they actually correspond to the uterus of such genera as *Choanotenia*, *Hymenolepis*, etc. The spaces indeed to which I here refer are more comparable, as it appears to me, to those of the *Dipylidium*, which have already been described in the present paper, and to be rather lacunae in the medullary network than deliberate pre-existing cavities at first united to form a single cavity. I believe, indeed, that there is no such fragmentation here of a pre-existing uterus as, for example, I have lately described\* in my genus *Otiditænia*.

For it is hard to believe that a uterus like that of so many tapeworms can exist in the present species. As already mentioned, in the more anterior proglottids, where the testes are fully ripe and the ovaries fully formed, there is no trace of any sac which might be considered to be a uterus. Nor, indeed, among the closely adpressed testes which occupy so much of the interior of these proglottids does it seem that room exists for the development of a uterus. In any case nothing obvious of the kind is visible. It is in riper proglottids which are more elongated in their form that the "uterine" spaces referred to are first visible. They lie (text-fig. 93) scattered among the testes,

\* "On a New Genus of Tapeworms (*Otiditænia*) from the Bustard (*Eupodotis kori*)," P. Z. S. 1912, p. 194.

and are developed in the posterior region of the proglottid only, but all the same occupy the greater part of such proglottids. There is no regularity in the dispersal of these cavities, so far as I have been able to make out. They lie here and there, and are never crowded like the testes; among them lie the remains of the testes in the most posterior segments, where the testes are most fully reduced. The cavities increase in size *pari passu* with the development of the embryos contained within them. In the more anterior part of the body the spaces are small and contain but a single egg or embryo just commencing to divide, which does not nearly fill the cavity.

Text-fig. 93.



*Diplopylidium genetta.*

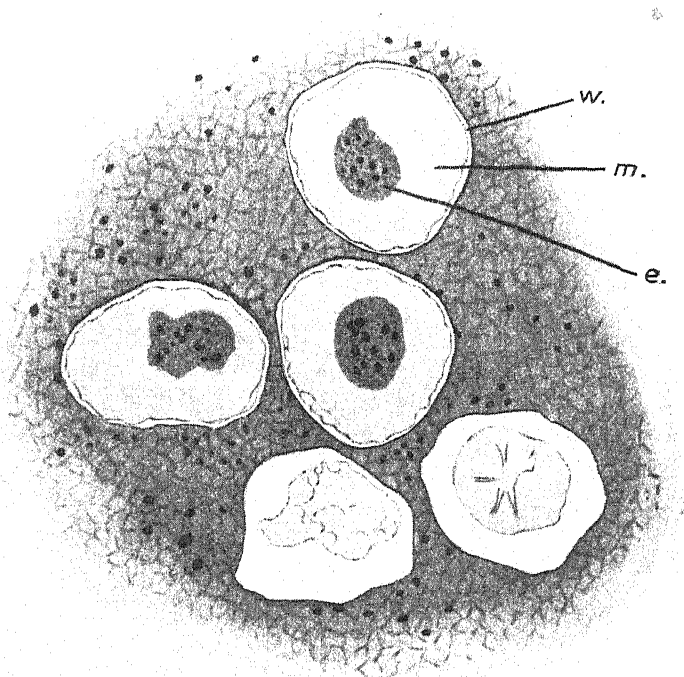
A portion of a nearly ripe proglottid showing ova (e.) lying in spaces in the medulla.

In the centre of the field is one ovum which has no cavity round it.

Further back the cavities are larger to accommodate the large embryo with its wide egg-shell. Nowhere is there anything of the nature of a lining membrane to these cavities. No nuclei are distinguishable as forming a layer immediately surrounding them, though the nuclei of the medullary parenchyma are, of course, to be found frequently in the neighbourhood of the limiting layer of the cavities; but in these cases there is no

relation to be observed between these cells and the egg-holding spaces. I have never found more than a single embryo in one cavity; if there are occasionally more, such instances must be rare. The accompanying drawing (text-fig. 94) shows a number of the embryo-holding spaces in a fully ripe proglottid. It will be noticed that between the embryo itself and the wall of the sac in which it lies is a tumbled mass of a membranous appearance.

Text-fig. 94.



*Diplopylidium genetæ.*

A portion of a more fully mature proglottid. The embryos are now surrounded by a delicate often crumpled membrane, and the spaces in which they lie are larger.

*e.* Embryo. *m.* Egg-membrane. *w.* Cavity surrounding embryo.

This is not all stained by the hæmatoxylin, which has amply stained the embryo itself and the surrounding tissues of the medulla. The inference, therefore, appears to be that this membranous material is in reality the egg-shell and is of a chitinous nature. In some cases it has a more regular

appearance, and seems to lie in concentric layers surrounding the embryo; in others this is not apparent, and it even simulates a retiform tissue in the laxity of its arrangement.

The ultimate arrangement of the uterine spaces in this worm is, therefore, the same as we find in the species of *Dipylidium* that has just been described. But the two genera differ in the fact that this is preceded in *Dipylidium* by another developmental stage not represented in *Diplopylidium*. In the latter we find the scattered cavities lying among the remains of the discharged testes, and as both a final and an initial stage. There is no intermediate condition that I have found where the ova are contained in larger cavities, which subsequently become reduced to chambers each containing a single egg such as is found in *Dipylidium*. The cavities in the two cases are, therefore, not exactly equivalent; otherwise, as has been said, there is a close agreement between the two worms. In neither can any lining membrane be detected forming a wall to the egg-cavities. The actual size of the individual spaces is much the same, but in *Dipylidium* they are more closely packed together. In formulating this difference between the two genera I rely upon what I have seen and not seen in my sections. It would be unwise—because of the negativity of my conclusions—to assert this fact in a more positive way by using it as part of the generic definition of *Diplopylidium*. It is not only in *Dipylidium* that we find a series of egg-holding spaces like those of *Diplopylidium*. The same kind of arrangement occurs in *Oochoristica*, so named on account of the scattering of the mature ova through the parenchyma. But in this genus there is an obvious uterus which exists before the final scattering of the eggs. Moreover, when imbedded in the parenchyma, the appearance is as if the eggs were firmly imbedded in the homogeneous ground material of the medullary tissue and not received into cavities. The eggs, in fact, are immediately surrounded by solid tissue and not by the rest of a cavity. More like the disposition met with in *Dipylidium* and *Diplopylidium* is that which is to be seen in *Monopylidium*, a genus to which the present genus, as I point out later, is probably related. But it should be remarked, first of all, that the absence or presence of a cavity round the singly imbedded ova is not a matter of great importance. For, as will be seen by an inspection of text-fig. 93, it happens occasionally in *Diplopylidium* that imbedded ova have no cavity round them. This may well be a preliminary state of affairs, the subsequently appearing cavities being due to the growth of the egg into the embryo. In this case there will be no doubt whatever that the egg-holding cavities of *Diplopylidium* are totally different from those of *Dipylidium dongolense*, since the latter are formed as subdivisions of an earlier larger cavity.

In *Monopylidium* the ova are in the same way scattered through the parenchyma in cavities which contain one, or in some cases more than one, ovum. It is evident, however, from

the definition of this genus by Ransom\*, that he regards these spaces as dissected portions of a pre-existing uterus. It seems clear, from the illustrations given by Mola†, that the egg-holding cavities are not lined by cells in *Tenia marchali* (a species which Fuhrmann refers to the genus *Monopylidium*), and in this fact we find an agreement with the two tapeworms described in the present paper. A very remarkable condition is described and figured by Fuhrmann‡ in *Monopylidium rostellatum*. In this species the eggs are scattered singly through the medullary region, and each egg fits closely into a hexagonal mass of delicate tissue, which itself fits equally closely into the medullary parenchyma, leaving no gaps or spaces anywhere. It seems to me to be just possible that this "parenchyma vacuolaire" which immediately surrounds the egg may be simply the outer egg shell, which I have myself observed in *Diplopylidium*, when crumpled, to present quite the appearance of a retiform tissue. It is finally to be noted that the disposition of the mature ova in *Diplopylidium* is perhaps also to be compared to the scattering of the eggs in *Inermicapsifer capensis*§ before the inclusion of these in the parenchymal organs. But it must always be borne in mind that in the case of *Diplopylidium*, *Oochoristica*, and *Monopylidium*, completely mature proglottids may not yet have been seen. A final stage may be the formation of paruterine organs, though this does not seem to be very likely.

We may characterise this new form as follows:—Size small, up to 6 mm.; number of segments up to 28. Scolex with retractile muscular rostellum armed with two rows of hooks, 17 in each row. Suckers unarmed. Neck short; posterior proglottids two or three times as long as broad. They do not project posteriorly or overlap. Generative orifices lateral and paired in each proglottid, opening at or rather in front of the middle of the proglottid. The ducts pass between the longitudinal water-vascular tubes. The female orifice is situated in front of the male. The water-vascular tubes are two on each side, the dorsal being of narrower calibre; they are placed one above the other. A longitudinal muscular layer, only a few fibres thick, separates the cortical and medullary regions. The testes are numerous and large, filling up all the proglottid not occupied by other parts of the generative system; testes disappear in posterior proglottids when egg-chambers appear. The cirrus-sac is large, with muscular walls, not lying in one straight line, but bent backwards in relation to the fact that there are two in each proglottid. The cirrus is very slender and coiled within its cirrus-sac. The sperm-duct is coiled and lies on each side in front of cirrus-sac. Ovaries distinctly paired in each proglottid, lying laterally behind the

\* "The Tænioid Cestodes of N. American Birds," Bull. U.S. Nat. Mus. no. 69, 1909, p. 76: "Uterus breaks down into egg-capsules."

† Bull. R. Ac. Belg. 1907, p. 806.

‡ "Nouveaux ténias d'Oiseaux," Rev. Suisse Zool. xvi. 1908.  
P. Z. S. 1912, p. 586, text-fig. 76.



generative pores and at the middle of the segment; each ovary lies in front of the corresponding vitelline gland. The vagina is narrow and passes forward, running in front of and parallel to terminal section of cirrus-pouch; posteriorly it dilates into a receptaculum seminis lying close to and in front of ovary and behind dilated region of cirrus-sac. Uterus as a simple cavity is absent (?). The developing ova are lodged singly in cavities of the medullary parenchyma, which they nearly fill, and are without any lining epithelium. Eggs with very wide but delicate shell.

From this general résumé we may now endeavour to form a generic definition of *Diplopylidium* by eliminating from the above characters those which are in all probability to be regarded as only specific in value.

### *Diplopylidium*, gen. nov.

*Retractable muscular rostellum armed with two circles of hooks. A double set of reproductive organs in each proglottid. Genital canals pass between dorsal and ventral excretory tubes. Vagina lying in front of cirrus-sac. Cirrus-sacs large and muscular, bent upon themselves; cirrus coiled, very slender, and unarmed; sperm-duct forms a coil. Testes numerous, filling up available space in proglottid. Ovaries two, in front of vitelline glands. Vagina narrow, with receptaculum seminis. Uterus represented by numerous cavities, each containing one egg only.*

We have now to consider the affinities of this tapeworm and the family within which it should be placed.

There is not a very large number of genera in which the reproductive organs are double in each segment. We find, however, such forms in nearly all of the families into which the Tetracotylean Cestodes are divided. We may at once place on one side those genera, such as *Cittotænia* and *Moniezia*, which belong to the Anoplocephalidæ; for in the genus which forms the subject of the present communication there are not, as in these forms, persistent uteri; and, moreover, the worms of the family Anoplocephalidæ are not provided with a hooked rostellum. Nor can we place the present genus, which I propose to term *Diplopylidium*, with either *Diplophallus*\* or *Diploposthe*, two genera which are nearly allied to each other, though placed by Ransom† in separate families, viz. the Acoleidæ and Tæniadæ. It must be noted, however, that Fuhrmann‡, in his well-known revision of the tapeworms of birds (those belonging to the Cyclophyllideæ), regards *Diploposthe* as not strictly referable to the Tæniadæ, but as forming an intermediate type between this family and that of the Acoleidæ.

\* For anatomy of *Diplophallus*, see Cohn, Zeitschr. wiss. Zool. lxvii. 1897, p. 277, and Wolfhügel, "Beitr. z. Kenntniss d. Vogelhelminthen," Inaug.-Diss. Freiburg-im-Br. 1898.

† Bull. U.S. Nat. Mus. 1909, no. 69.

‡ Zool. Jahrb., Suppl. vol. x. 1908.

Both of these genera have a rostellum which is armed with ten hooks. The greater number of hooks in *Diplopylidium* might be regarded as a difference of merely specific value. But while in *Diploposthe*\* and *Diplophallus* the uterus is persistent, and in mature segments occupies an enormous amount of space in each ripe proglottid, *Diplopylidium* has probably not a persistent uterus at all; or, if the spaces containing eggs which have been described above are to be looked upon as remnants of a uterus or of uteri, the conditions are obviously very different. This important difference, as it appears to me, renders any confusion between these forms quite impossible. I have referred above to certain other comparisons between my genus and the two that have just been compared with it.

My genus presents certain points of likeness to the genus *Cotugnia*, founded by Diamare in 1893†. The chief point of likeness is that in *Diplopylidium* the ripe eggs are imbedded singly in the medullary parenchyma, as is stated to be the case with *Cotugnia*. But in the latter genus, Fuhrmann‡, though he gives no figures showing detail, speaks of a "parenchymkapsel" as surrounding the eggs. This is probably to be compared to that of the allied *Davainea*, and, therefore, presumably is not like that which I describe in the present paper. The vagina, too, of *Cotugnia* has a dilated receptaculum seminis. Otherwise I do not think that the two genera can be confused. The worms are rather large species, and the rostellar hooks are numerous and minute, and have the typical Davaineid form which is unlike that which I find in *Diplopylidium*. But *Cotugnia* appears to differ from other Davaineids in having no hooks upon the suckers. ["Ventose grandi e inerme" (Diamare)], and thus to approach *Diplopylidium*, to which its double generative pores and possibly the nature of the egg-cavities affine it.

It may be furthermore pointed out that the genus *Cotugnia* seems to be characterised by its short and broad proglottids, in which it clearly differs from the worm upon which I report in the present communication. Diamare†, in his paper upon *Cotugnia* (and other tapeworms), assigns to his new genus a species described by Monticelli§ from material named by von Siebold. This species (" *Tenia bifaria* ") has, as it appears to me, rather more claims to be allied to my genus *Diplopylidium* than to *Cotugnia*, if Diamare is right in supposing Monticelli to have overlooked the rostellar hooks. For in his figure|| of the generative organs (which is repeated in Bronn's 'Thierreichs'¶),

\* For the anatomy of *Diploposthe*, see Jacobi in Zool. Jahrb. x. Anat. Abth. 1897, p. 287; Kowalevsky, Bull. Ac. Cracow, 1903, p. 518, for a brief account of *Diploposthe sui-generis* n. sp. (?); and Fuhrmann, Centralbl. Bakt. xl. p. 218, for a general résumé of this genus.

† Boll. Soc. Nat. Napoli (1) vii. 1893, p. 11.

‡ "Neue Davaineen," Centralbl. f. Bakt. u. Paras. xlix. p. 115; and Zool. Anz. xxiv. 1901, p. 273.

§ Boll. Soc. Nat. Napoli (1) v. 1891, p. 151.

|| Loc. cit. pl. viii. fig. 12.

¶ Pl. lvi. fig. 9.

Monticelli places the vagina in front of the cirrus-sac as I have found it in *Diplopylidium*. But this tapeworm has a cirrus which is armed with spines which I have not found, and which also does not seem to occur in *Cotugnia*. Nor does Monticelli say anything of the eggs: which makes any comparison more difficult. The segments, however, are more elongated than in *Cotugnia* and thus like those of *Diplopylidium*.

Passing by the family Amabiliidæ, of which the type-genus *Amabilia* has double reproductive organs, and to which *Diplopylidium* does not, as it appears to me, show any affinities, we come to the Hymenolepidæ. To this family, and especially to the subfamily Dipylidiinæ (in the sense of Ransom), *Diplopylidium* shows points of likeness. In this subfamily there are two genera, viz. *Dipylidium* and *Pancerina*, which have reduplicated generative organs. After the description of a *Dipylidium*, which I have given in the present paper, I do not think it necessary to emphasize further the distinctness of *Dipylidium* and *Diplopylidium*. As to *Pancerina*, that genus has no hooks upon the rostellum; it may be merely an *Oochoristica* with double generative organs, or, as I have suggested elsewhere\*, an Ichthyotæniid. Our knowledge of its anatomy is at present insufficient to place it with accuracy.

But although *Diplopylidium* is certainly not identical with *Dipylidium*, it agrees with that genus and some other Dipylidiinæ in the characters of the egg-holding spaces (which I do not term uterus for reasons given above)†. It is obviously quite near in this respect to the species of *Dipylidium* which I describe in the present paper. *Oochoristica* also has the ripe ova scattered at random through the medullary parenchyma‡. *Monopylidium* has also the same type of egg-holding cavities which I have referred to more at length above in describing this part of the generative system of *Diplopylidium*. Furthermore, in *Monopylidium* there are species (e. g. *M. macracanthum* §) where the hooks are not very numerous (22) and arranged in two circles. On the whole, I am inclined to place my genus in the near neighbourhood of *Dipylidium* and *Monopylidium*.

\* P. Z. S. 1913, p. 6.

† *Supra*, p. 567 etc.

‡ Cf. e. g. Beddard, P. Z. S. 1911, p. 633, text-fig. 150c.

§ Fuhrmann, Centralbl. f. Bakt. u. Paras. xlv.

37. Pacific Salmon: An Attempt to evolve something of their History from an Examination of their Scales. By JOHN ADAM MILNE, of Ardmiddle, Turriff, Aberdeenshire\*.

[Received April 9, 1913; Read May 6, 1913].

(Text-figures 95-118.)

SALMONIDÆ: STRUCTURE, DEVELOPMENT, ETHOLOGY.

The above title indicates what is perhaps a somewhat bold venture on the part of one who lives on the east side of the Atlantic, and who has only once seen a freshly killed Pacific salmon during a short visit to Vancouver in 1893. The reasons for my undertaking it are that, so far as I have been able to ascertain, the study of salmon scales has not yet made much progress in America, that undoubtedly much may be discovered from them, and that even such inadequate observations as I have been able to make may afford most valuable hints to others better able to procure materials for the study of the habits of the so-called salmon of the Pacific. I say *so-called*, because with one exception, *Salmo gairdneri*, the Steelhead Trout, the Pacific salmon do not belong to the same division of the genus *Salmo* as the salmon of the Atlantic Ocean. Excepting the Steelhead, they belong to the subgenus *Oncorhynchus*, while our salmon and trout belong to the subgenus *Salmo*.

I shall have to notice five species of *Oncorhynchus* which breed in the rivers and streams of Western North America. They are *O. quinnat*, or *O. tschawytscha*, the Quinнат, King, Tyee, or Spring Salmon; *O. nerka*, generally known as the Sockeye, from the sunken appearance of the eyes, and also called the Blueback and the Red Salmon; *O. kisutch*, the Cohoe, Silver, White, or Fall Salmon; *O. gorbuscha*, the Humpback, so called from a peculiar hump which appears on the backs of the males at spawning time; and *O. keta*, the Dog or Chum Salmon. A sixth species, *O. masu*, is found on the Siberian coast and in Japan, but I shall not deal with it here, as I intend to confine my remarks to the salmon of the Pacific coast of North America. It is there that full knowledge of the habits of the Pacific salmon is of the greatest importance on account of the magnitude of the canning industry, to which every one of the native species now contributes its quota.

When the canning industry was first started in the West, the Quinнат only was cared for, but soon the Sockeye was recognized as a fish of much greater importance. The value of the remaining species has only recently been appreciated.

It is generally believed that none of the fish of the genus *Oncorhynchus* that go to the rivers ever return and that all die after

\* Communicated by the SECRETARY.

spawning. But although the upper tributaries of the Fraser River are almost unapproachable for some time after the spawning season, on account of the numbers of dead and putrefying fish which they contain, I do not think it is absolutely proved that all the fish do die after spawning. Later on I shall produce something approaching a proof that they do not. Most of them undoubtedly do die then. Many of our Atlantic salmon are so exhausted after spawning that they promptly die. Much more so must that be the case with these Pacific salmon, which ascend the rivers not for a few tens of miles as our fish do, but for some hundreds, or even for many hundreds of miles. The probability certainly is that when they go very far from the sea, none of them return. But they do not all ascend to extreme distances; and I can see no reason why some of those which have not had far to go, or great difficulties to surmount on the journey, should not have sufficient strength to recover and to spawn again. I well remember the manager of one of the largest canneries on the Fraser saying to me that the idea that all the fish died was based on the statements of Indians only; that no one else knew anything about it (I speak of twenty years ago), and that millions of kelts might come down the middle of the Fraser with the stream, and not a soul be any the wiser. To my mind the fact that no kelts are ever seen does not prove their absence. No netting is going on when the kelts would come down, so, as no Pacific salmon can jump, and as no Pacific salmon has ever been known to take a bait in fresh water, it is most improbable that they would be seen.

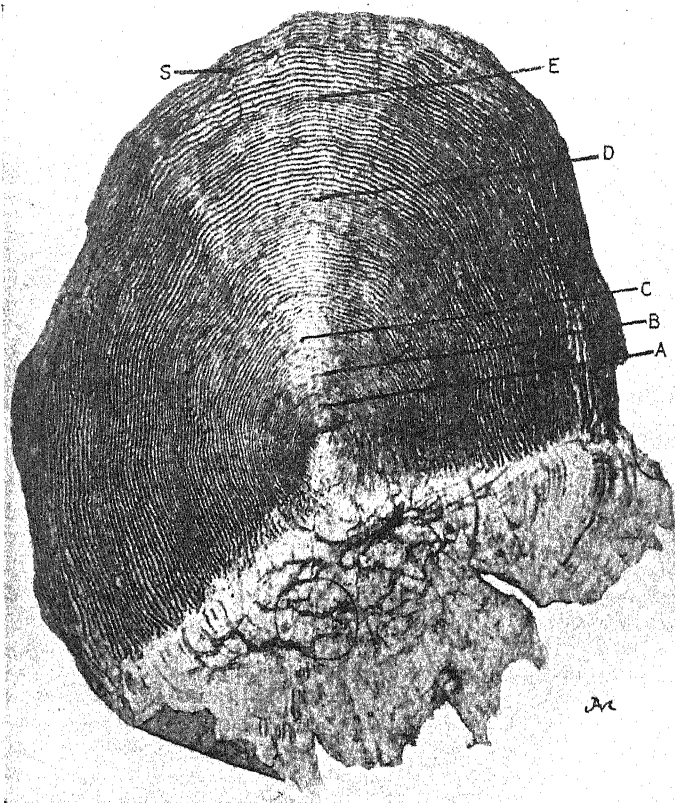
It was in the hope that some definite evidence might be forthcoming upon this point that I first took up the study of the scales of Pacific salmon. One certain spawning mark would disprove the idea that every fish dies. But even on our Atlantic Coast the percentage of fish that are recaptured after having spawned is very small; and on the Pacific Coast the percentage must, for the reasons mentioned, be much smaller. Supposing it to be as high as one in a hundred, which it probably is not, it might be necessary to examine the scales of some thousands of fish before that one happened to be among them. I have not been able to examine the scales of more than a few dozens, but I think that I have been so lucky as to find a spawning mark on the scales of a large Quinuat. One of its scales is shown in text-fig. 95 (p. 574), and I believe that the mark about a quarter of an inch from the edge of the photograph is a spawning mark. I shall have more to say about it later on when I come to deal with the Quinuat salmon in detail.

As against the general belief that Pacific salmon never survive spawning, I have heard the argument that the largest Quinnats, which weigh from 50 to 100 lbs., must be very old fish and that they must almost certainly have spawned. In text-fig. 96 (p. 575) is shown the scale of one which weighed 62½ lbs. It has certainly not spawned, and it is also certainly not old. It appears to be

only in its fifth year but to have grown very regularly and fast both in summer and winter throughout its life.

As I have to reason largely from analogy, I must now digress for a time from my immediate subject to say a little about what has been discovered from the scales of our salmon, *Salmo salar*, which is also the salmon of the east side of the American continent.

Text-fig. 95.



Scale of a Quinuat (*Oncorhynchus tshawytscha*) 33¼ lbs. Length 41½ ins.; girth 25½ ins. Captured at New Westminster, B.C., in 1912. Supposed spawning mark shown at S.

It appears to have occurred to Leuwenhoeck so long ago as the year 1696, and to Réaumur in 1716, that the concentric lines which are to be found upon the outer surface of the scales of most fishes are formed with some relation to the age of the scale, and therefore must give an indication of the age of the fish to which

the scale belongs. But no very close or reliable investigations as to how the ages of salmon might be read from their scales were made until Mr. H. W. Johnston took up the study a few years ago. Although I am not actually quoting from anything he has written, I think his authority for everything I am going to say, unless I may quote someone else, will be found in one or other of his contributions to the Reports of the Scottish Fishery Board. (See Parts II. of the Reports for 1904, 1906, and 1907.)

Text-fig. 96.



Scale of a Quinuat (*O. tshawytscha*) 62½ lbs., ♂. Length 50¾ ins.; girth 31 ins.  
Captured at New Westminster, B.C., in 1912.

A salmon scale is divided into two areas, one, the anterior and larger part, being enclosed in a pocket in the skin, to which it is loosely attached; the other, the posterior area, being the only part of the scale which we see while it is still attached to the

fish. The anterior part is covered by a mass of concentric lines or ridges, from the relative positions of which much may be learned. The posterior part is almost without lines. This formation is common to the scales of all members of the genera *Salmo* and *Oncorhynchus*. The whole scale is covered by a membrane and grows with the fish. When the fish—and with the fish, the scales—grows slowly the concentric lines, which seem to be produced at a fairly uniform rate as to number, are situated closely together; when they grow quickly the lines are placed further apart. When the fish does not grow at all, the scales also cease to grow, and no lines are added to their surfaces. The scales first appear upon young salmon as minute bony plates under the skin. They may first be noticed when the fish is about three months old, and about  $\frac{3}{4}$  inch in length (Vogt, 'Embryologie des Salmones,' 1842, Klaatsch 1890, and Dahl, 'Age and Growth of Salmon and Trout in Norway,' 1912). When about four months old and  $1\frac{1}{4}$  inches long the little fish may have from 2 to 5 rings round their scales; and when about eight months old, that is just before the winter comes on, there may be, roughly speaking, from 8 to 20 lines already visible on each of their scales. Within small limits the number of lines varies in different scales even from the same fish. We know that the yearlings when kept in ponds feed well and grow rapidly during the summer months, and that as winter approaches they take less nourishment, finally at times fasting completely for three or four days on end. We also know that their growth progresses in proportion. This mode of life is clearly depicted on their scales. Surrounding the nucleus, the lines formed in summer are at some small distance from each other, and each line can usually be traced right round the scale. The lines formed in winter are much closer together and are usually more numerous on the anterior portion of the scale.

When the growth of the next year begins in the spring, the lines first formed are again wider apart and generally continuous all round the scale, and, later on, the winter formation of the first year is repeated. Thus there is formed an area of well-spaced lines followed by a band composed of lines very close together. This band is usually most noticeable in front, and is followed by another area of open lines and a second band which is probably not quite so well defined as the first. The accompanying photograph (text-fig. 97) of the central part of the scale of a Steelhead Trout (*S. gairdneri*) well illustrates the formation. The line A points to the completion of the first winter band, B of the second winter band, C of the third, and the end of the line D shows the point in the next year when the smolt left the river and commenced to grow rapidly in the sea.

In the sea growth proceeds as before, but at a much increased rate, and the difference between fast summer and slower winter growth continues to be apparent on the scales.

Fish that are born, and spend all their lives in the sea, show



annual winter bands like the others ; but, except for these bands, the spacing between the lines shows no sudden increase due to any abrupt change in the mode of life. Compare text-fig. 98, the photograph of a scale of a large haddock, with the other photographs illustrating this paper, and the difference in the

Text-fig. 97.



Centre of scale of a Steelhead Trout (*S. gairdneri*) from the Fraser River, much magnified, showing three winter bands before migration to the sea. (For references see the text, p. 576.)

centres will be at once apparent. I wish to emphasize this difference because the Pacific salmon scales, if we except those of *O. keta*, the Dog Salmon, show a sudden change of growth just as do those of the true salmon ; and this, to my

mind, at once disposes of the idea that these fish go down to the sea almost as soon as they are hatched and commence feeding only when they get there.

Text-fig. 98.

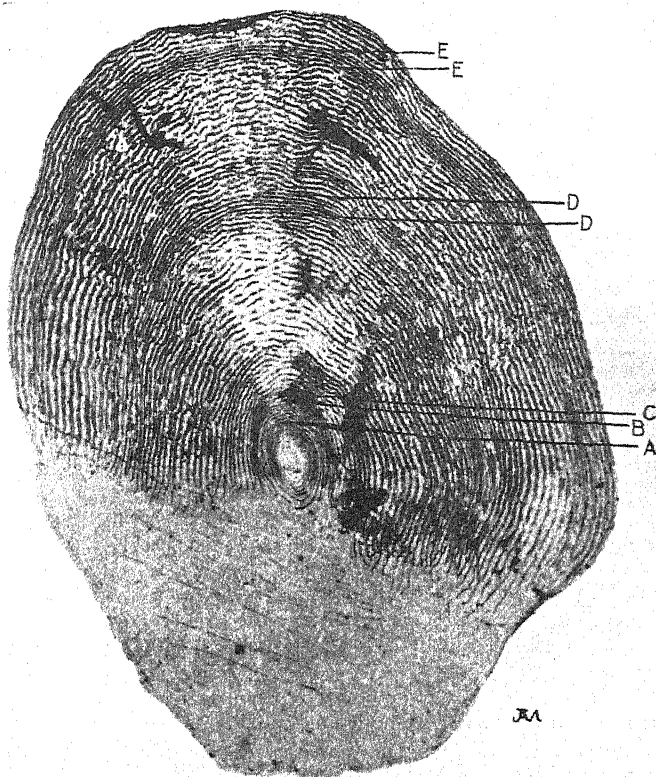


Scale of a large Haddock (*Gadus aeglefinus*).  $\times$  about 40.

Mr. Johnston kindly gave me some of the scales taken from salmon which had been marked as smolts in the estuary of the Tay in the early summer of 1905. The smolts were then on their way to the sea, and the marks were still attached to the fish when subsequently recaptured as salmon. Thus the exact times spent by them in the sea were known, and it was found, as had been expected, that the summer and winter bands on the

scales agreed with the known times. Text-fig. 99 is a scale from one of these fish which was captured in the Tay nets on May 7th, 1907. It had been marked as a smolt when the scale had grown to the point C, and when the fish was just over two years old. The winter band formed in the winter 1905-6 is apparent between the points marked D, and the band formed in the winter

Text-fig. 99.



Scale of 12½ lb. salmon (*Salmo salar*) caught in the Tay nets on May 7th, 1907. Previously marked as a smolt in May 1905. (For references see the text, *supra*.)

1906-7 between the points E. Outside the last band is seen the quick growth made in the summer of 1907 previous to May 7th, when the fish was netted. Summer growth is the term used in distinction to winter growth. It does not mean growth taking place only in June, July, and August, our summer months. It evidently starts and finishes at varying times, the probable

limits being about the middle of March and the middle or end of September.

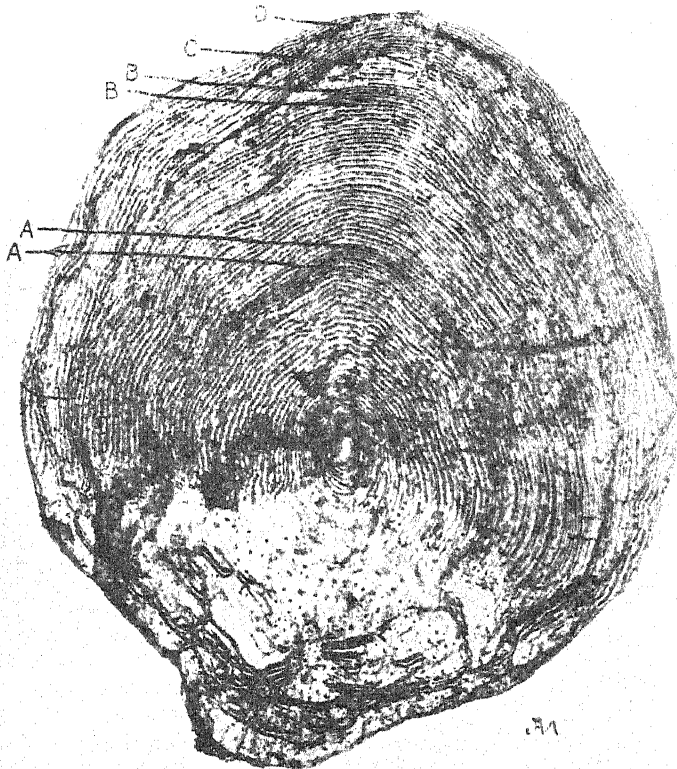
The foregoing remarks may suffice to explain the regular markings on salmon scales, and how they show the age and time of migration of the salmon. Scales, however, may show much more.

Mr. Johnston noticed that the scales of the older fish sometimes seem to have stopped growing, and become jagged and broken at the edges, and then to have gone on growing again. When this has happened the lines of the new growth do not exactly follow the contours of the lines of the old growth, and thus a clear mark is formed round the anterior portion of the scale, often also apparent as a thickening round the posterior, the unlined, portion. Further, it was noticed that when such a mark occurred the number of lines between the winter bands on each side of it was frequently far from normal. The normal number differs somewhat in different fish, and also within certain limits on scales from different parts of the same fish; but nevertheless it is fairly constant, and any wide departure from the usual state of things required explanation. A reason for the mark suggested itself to Mr. Johnston from the known fact that salmon, whether or not they take food in fresh water, do not take it in sufficient quantity, after the smolt stage is passed, to nourish them. Therefore neither salmon nor their scales can grow in fresh water. It was further noticed that most scales taken from kelts—that is to say from salmon which, having spawned, have not yet returned to the sea—were broken and torn at the edges. From these facts Mr. Johnston argued that the sort of marks illustrated at C and D on the accompanying photographs (text-figs. 100 & 101) showed that the fish bearing them on their scales had entered fresh water and stopped growing there; that they had spawned and become shrunken after spawning, so that, from mechanical reasons, the scales being imbricated, *i.e.* overlapping each other like tiles on a roof, had become frayed at the edges; and, lastly, that on the salmon's return to the sea the new growth had started again evenly round the scale and thus left the mark. Spawning operations mean a winter at least spent in fresh water and, therefore, if the fish enters a river early in the year there will be fewer than the normal number of lines between the winter bands formed on each side of the spawning mark. If it comes in early in the spring there will be none in that year, and in the year following there will be fewer than usual on account of the fish taking some time after its return to the sea to make up lost condition before it starts again to increase in size. Of course, the later the salmon came into the river the more lines would have been formed behind the mark, and the later it returned to the sea the fewer would there be in front of it.

Besides the irregular arrangement of the lines on the scales when a fish has spawned, there is a thickening round what was

the edge of the scales at the time the salmon left the sea, and this thickening is apparent both on the anterior and posterior parts of the scales if the edges have not become too much worn during the stay in fresh water. I account for it by supposing that the materials which go to form the scales are still being secreted in fresh water, and that as the skin

Text-fig. 100.



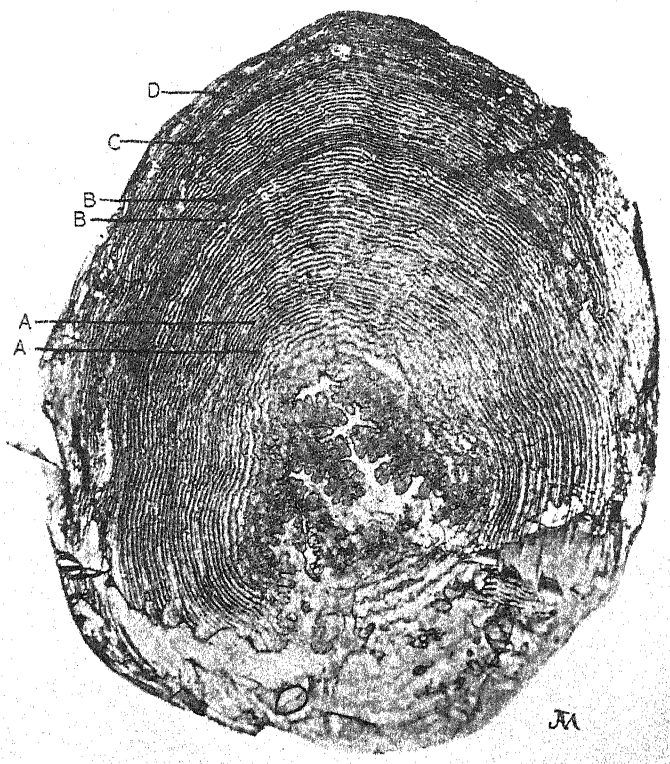
Scale of 33 lb. Salmon (*Salmo salar*) caught in the Tay in August 1903.

This fish had spawned twice, and the marks are shown at C and D.

pockets have ceased to grow they can be deposited only on the scale edges already formed. The cells from which the concentric lines on the upper surface are evolved are already dead, except close to the periphery of the scale (Klaatsch, 'Zur Morphologie der Fischschuppen,' 1890, and Stuart Thompson, 'Journal of the Marine Biological Assoc.' vol. vii. no. 1, 1904). This in itself

would account for the marginal thickening if the cells still remain active in fresh water and the scale cannot expand.

Text-fig. 101.



Scale of a 33½ lb. Salmon (*Salmo salar*) caught at Port Gordon, Aberdenshire, on August 19th, 1908. Previously marked as a kelt on the Deveron, March 23rd, 1908. This fish had also spawned in the previous year, and the two marks are shown at C and D. The original scale has been lost at the end of the first summer in the sea, and its position filled by a new scale without lines.

On both text-figs. 100 & 101 two spawning marks are to be seen, but the figures illustrate what I have just said as well as if they had but one mark. Scales which like these show two marks are far from common. The central part of text-fig. 101 is without lines, so that the parr scale does not show at all. This is because the original scale was lost by the fish towards the end of its first summer in the sea, and the place occupied by it in the skin pocket was filled by a new scale which, the line producing

cells having died, is devoid of concentric lines. In both text-figs. 100 & 101 the first winter band formed in the sea is shown between the ends of the lines AA. The second winter band is between the lines BB. The first spawning mark in each case is at the end of the line marked C and the second spawning mark at D. Text-fig. 100 is a scale from a 33 lb. salmon caught in the Tay in August 1903. It can be seen, from the few widely spaced lines between the band BB and the spawning mark C, that when it first spawned it was a summer fish about  $4\frac{1}{2}$  years of age. After spawning the scale had become much worn, so much so that, except in front, not only the summer growth but the band BB had disappeared, and the new growth formed after the fish returned to the sea can easily be distinguished, its lines being again continuous round the scale. In text-fig. 101 the winter band of the 5th year had begun to form before the spawning mark C, so it was evidently a late autumn salmon. In text-fig. 100 the second spawning mark is indicated by the line D. The fish must have returned to the sea after the first spawning early in the year, and the lines between the two spawning marks show it to have come in to spawn the second time late in the summer of the same year. The following summer it was coming back to spawn a third time when it was captured. The thickening on the posterior part of this scale, due to both spawning periods, is clearly visible in the form of dark lines. In text-fig. 101 the second mark D, like the first mark C, denotes an autumn fish. It is not a very clear spawning mark, but I have chosen it for that very reason, because it is so like the mark on the scale of the Quinntat which I believe to have spawned (see text-fig. 95, p. 574) and because I have undoubted evidence that mark D on text-fig. 101 is a true spawning mark. The fish was caught as a kelt, weighing  $22\frac{1}{2}$  lbs., and marked by my own gamekeeper, Peter Bowie, at Netherdale on the River Deveron, on March 23rd, 1908. He put in its fin one of the Scottish Fishery Board labels numbered 3613 B. The scales then showed only the first spawning mark C. The fish was recaptured as a clean salmon, weighing  $33\frac{1}{2}$  lbs., in a bag-net at Port Gordon on the Aberdeenshire coast on August 19th, 1908, after only five months' interval. The mark D thus certainly represents the second spawning period during which my keeper caught and marked the fish.

Many other instances have occurred in which fish that have been marked with distinctive numbers as kelts have been caught again, and in every case they have proved the truth of Mr. Johnston's theory by showing a spawning mark on their scales. On the other hand, no fish that one knows from its age could not have spawned has ever been found to bear quite the same sort of mark, although various marks indicating sudden checks in feeding may appear.

I have entered somewhat fully into the above description of spawning marks, because I hope that now many scales of Pacific

salmon will be examined upon the chance of finding one. Much can be done with an ordinary high-powered pocket-lens, and for close observation only a very low-powered microscope is either necessary or desirable. I find a  $1\frac{1}{2}$ -inch objective powerful enough for all purposes. One wants to be able to see as much as possible of the scale at the same moment.

Mr. Knut Dahl ('Age and Growth of Salmon and Trout in Norway,' London, 1912) has shown that the size of a fish at any period of its life may be deduced from its scales.

A fish does not change its scales. From the time they form they are retained through life unless removed accidentally. If a fish does by chance lose one it is replaced by another of the same size and shape but without the concentric lines—see text-fig. 101. It follows that as the fish grows, but remains covered by the same number of scales occupying the same relative positions, the scales must grow with the fish, and the growth of each scale be proportionate to the growth of the fish. If, then, the protected part of the scale be measured along its length from the centre to the anterior edge and again from the centre (by which I mean the nucleus) to, say, the first winter band, the lengths of the scale at these two points will be proportionate to the lengths of the fish at corresponding ages. An example will make this more clear. Suppose we have a salmon 75 cm. long and that one of its scales, when magnified, measures 55 mm. from the centre to the anterior edge, and 11 mm. from the centre to the point at which the rapid growth, consequent on migration to salt water, is seen to begin. Then as 55 is to 11 so is 75 cm. to the length of the fish when it entered the sea. The smolt was therefore 15 cm. (or just under 6 inches) long. Another scale from the same fish magnified to the same degree, might be only 45 mm. long, but then the other measure would be found to be 9, and the sum would work out just the same.

Dahl has proved his theory by measuring the scales of hundreds of salmon and trout from different rivers. He has always found that the actual average lengths of the fish in different rivers at various ages, agree almost exactly with the lengths calculated by him from the scales of the older fish.

I have been trying to apply this method of measurement to the scales of Pacific salmon, and I will give the results when I come to deal with each species separately. First, however, I must make some criticisms on what I have set out above as my understanding of the claims made by Dahl. I tried to check his theory on the scales of two salmon which had been marked as kelts and subsequently captured as clean salmon. Photographs of both of these scales form illustrations to Mr. Johnston's second paper on salmon scales in the 25th Annual Report of the Fishery Board for Scotland. The lengths, on the occasion of each capture, are given elsewhere in the 24th and 25th Reports, so it is known that the salmon marked No. 9194 was 27 inches long when taken as a kelt, and 31 inches



long when recaptured. The other fish, marked 1180, was  $26\frac{1}{4}$  inches long as a kelt and 36 inches long when recaptured. The measurements on the photographs of the scales from the centre to the anterior edge, and from the centre to the spawning mark are 130 and 116 for No. 9194, and 198 and 175 for No. 1180, the unit of measurement being  $\frac{1}{64}$ th inch. This would give the kelt measures as  $27\frac{3}{4}$  inches and 32 inches respectively. The former measure is only  $\frac{1}{2}$  inch wrong, but the latter is nearly 6 inches wrong, and shows either that the scale is abnormal or that Dahl's system of measurement is not applicable to a fish that has spawned.

Another criticism is that measurements from several different scales of the same fish seldom all agree exactly, and I have therefore come to the conclusion that it is very unsafe to rely on the measurement of one scale in estimating the size of the fish at various ages. The reason may be that it is not easy to recognize either the *exact* centre of growth, or the *exact* limits of the

Text-fig. 102.



Quimmat (*O. tshawytscha*). 25 lbs. 13th October, 1911. Shuswap,  
South Thomson River.

The black lines show the variations in the long axis of the scale.

various bands, but I do not think that the scales grow quite equally. Still the idea seems so well founded in theory, and to have worked out so exactly in practice on a large scale in Norway, that I believe I may consider myself justified in drawing conclusions from the average measurements of a considerable number of scales taken from the same fish, and whenever possible, I have measured 20 scales. A smaller number might suffice in the case of a true salmon, but the scales of the Pacific salmon are more difficult to read. As a rule, the limits of the bands are less

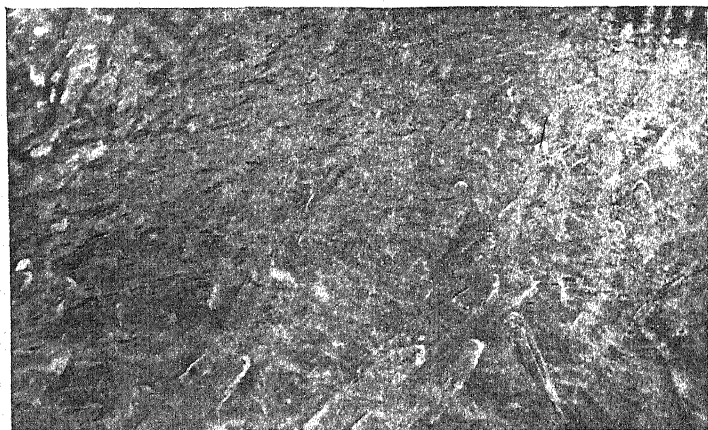
clearly defined, and the change of growth, which I can only suppose to be due, as in the case of the true salmon, to the commencement of sea life, is more gradual and not so well marked. In addition to this, the long axis of the scale frequently shows more than one change of direction, the scale apparently being liable to get turned round in the skin-pocket. The accompanying photograph (text-fig. 102) will show my meaning. I have not measured such scales as these.

To come now to what is known, and to what I think I may claim to have found out about the various species of Pacific Salmon.

#### THE SOCKEYE. (*Oncorhynchus nerka*.)

First I take the Sockeye, because it is the mainstay of the canning industry of the West. The number of Sockeyes canned on the Pacific coast in 1909 must have attained to the enormous total of about 50 millions. The exact weight was 214,980,448 lbs., or nearly 100,000 tons.

Text-fig. 103.



Sockeyes (*Oncorhynchus nerka*) running up Scotch Creek, a tributary of the Fraser River, British Columbia. (Photograph reproduced by kind permission of Mr. Frank Parry.)

The Sockeye is not much in evidence south of the Columbia River, in which it is known as the Blueback, but is plentiful from there the whole way north to Bering Sea. In Alaska it is known as the Red Salmon. The chief Sockeye stream is the Fraser River, which these fish ascend to spawn in countless myriads. The feeding-ground of the Sockeyes is somewhere far out in the Pacific, and the fish seem to cease feeding before they approach the coast, for even when caught in the sea near the coast their

stomachs are invariably empty. This, however, may be from lack of means rather than from want of will. When one hears of a shoal of fish, seven miles broad and of unknown length, heading for the land through the Straits of San Juan, one can well imagine difficulties in the commissariat. Part only of this big shoal enters the Fraser River, the remainder moves on up the coast of British Columbia. The photograph (text-fig. 103), which I give by kind permission of Mr. Parry, late of Granite Creek Hatchery, shows a detachment on its way up Scotch Creek, a tributary of the Fraser River, about 300 miles from the sea.

The big run of which I have been speaking strikes the south-west coast of Vancouver Island in July and August, coming from the north-west, but a few Sockeyes run as early as April. In the Fraser River itself the main run is in August, and some continue to come in until October. In the far north of Alaska the main run is as early as June, which goes some way towards showing that the feeding-grounds are in the north, unless a natural instinct to get spawning over before the winter sets in has determined the habits of the fish frequenting the most northerly rivers. In the Fraser district spawning begins in August, and may go on until November; spawning takes place only in streams running into or out of lakes. In this district, from which most of my information and all my specimens have come, several hatcheries have been established, which in 1910 liberated 134,639,200 Sockeyes in British Columbian waters. Besides these 4,544,825 were liberated from U.S. hatcheries in Puget Sound, and 257,021,790 in Alaska.

I am indebted to Mr. W. J. Sim, who was employed at Granite Creek for some years, for the information that the fry are liberated from the Canadian hatcheries as soon as the yolk-sac has been absorbed, at a period of the year which varies from January to April, according to the date of spawning. The main liberation is about the first week in February. In that district the fry may remain in the creek for two months or less; then they move into Shuswap Lake. The exodus from the lake takes place from June to September. The fry are supposed to be under one year old at the time of their exodus from Lake Shuswap, but no one really knows how long they may have remained in this, or in any other lake, and it is admitted by some observers that they may be in their second year. Dr. Greene, writing in the Bulletin of the U.S. Bureau of Fisheries, vol. xxix. 1909, on the Migration of Salmon in the Columbia River, and quoting Evermann, says the fry begin their seaward journey not sooner than September of their first, and not later than July of their second year. That means, I presume, that they leave the lakes when from nine to eighteen months old. But others, *e. g.* Rutter, Bulletin U.S. Bureau of Fisheries, vol. xxii. 1902, p. 102, say that they begin to descend the rivers as soon as they can swim, and reach the sea in about three months. Mr. Sim says he is certain that there are no fry in the rivers after September, and that they could not possibly avoid

being swept down with the current as soon as they leave the lake.

The question as to the age at which the fry enter the sea is one which scale-readings should easily settle. So far, I have been

Text-fig. 104.



Scale of Sockeye (*O. nerka*), ♂, 3½ lbs. Length 20¾ inches; girth 10½ inches.

A=end of first year's growth.

B=migration to sea.

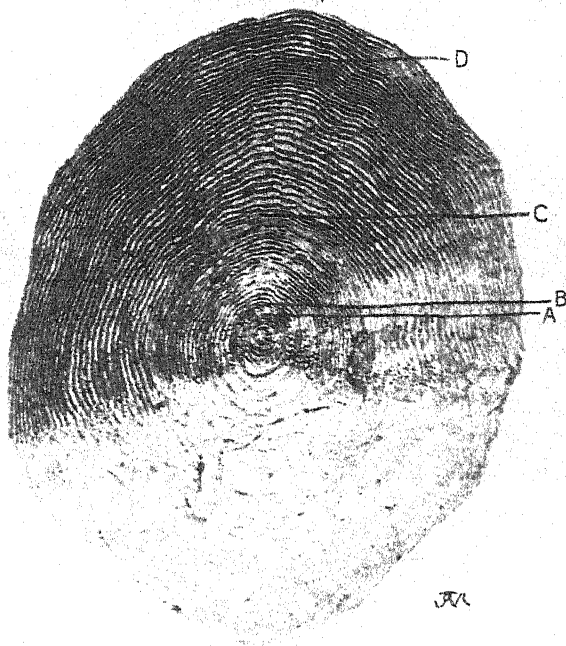
C=end of second winter,

D=end of third winter.

unsuccessful in my attempts to procure any specimens of fry of known ages for the purpose of seeing how their scales do actually grow, but I give some illustrations of Sockeye scales from full-grown fish (text-figs. 104-106). I have no doubt but that each

one of these Sockeyes spent a year at least in fresh water, and the first of them probably not less than 15 months. I can conceive of no other way in which scales with centres similar to these could have been formed. They are the only Sockeye scales which I have from measured fish, but I have others from six fish of which I know only the weights, and a great many more from Sockeyes that unfortunately were neither weighed nor measured. All have similar centres.

Text-fig. 105.



Scale of Sockeye (*O. nerka*) ♀. 5½ lbs. Length 24¼ inches; girth 12¼ inches.

A=end of first winter.

B=migration to sea.

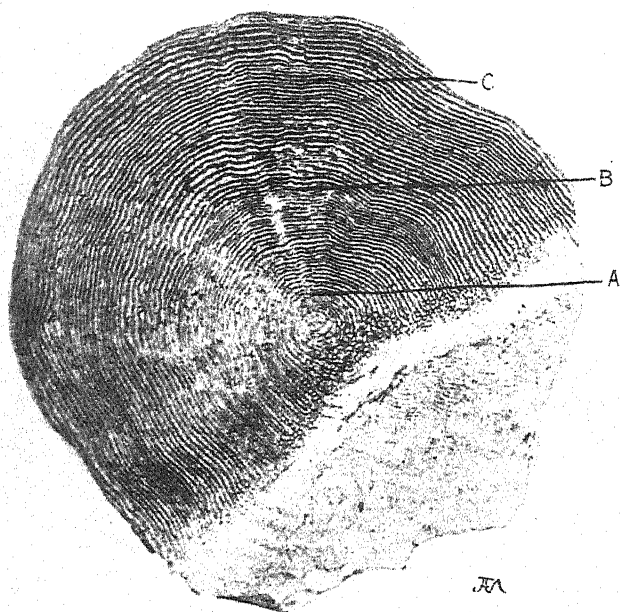
C=end of second winter.

D=end of third winter.

The Sockeye from which the scale, shown in text-fig. 104, was removed, was caught last August at New Westminster, near the mouth of the Fraser River. It weighed 3¼ lbs. and measured 20¾ inches in length and 10½ inches in girth when captured. I have measured 20 scales from this fish, the average length of the enlarged images to which I applied the measure being 33 mm. from the centre to the anterior edge. The other average measurements to the points denoted by the lines drawn on the

figure were 5 mm., 6.5 mm., 10 mm., and 20 mm., and the lengths of the fish at the various ages indicated work out as follows:— At the end of the first year  $2\frac{3}{4}$  inches; when it entered the sea  $3\frac{1}{2}$  inches, at the end of the second year 6 inches, at the end of the third year  $12\frac{1}{2}$  inches, and when caught it was as stated  $20\frac{3}{8}$  inches. The points indicated by the lines drawn on text-fig. 104 are calculated from the averages of the 20 scales, and they appear to coincide absolutely with the points I should have marked from examination of this scale alone.

Text-fig. 106.



Scale of Sockeye (*O. nerka*), ♂, 7 lbs..  $26\frac{1}{2}$  inches long; girth  $14\frac{3}{4}$  inches.

A=migration to sea at end of 1st year. B=end of 2nd year. C=end of 3rd year.

The next scale, text-fig. 105, is from a Sockeye caught at the same place and time. In the illustration the parr or fingerling scale is not very clear, but the examination of 20 scales enables me to put the lengths of the fish at the various points and times indicated by the lines drawn on the picture as follows:—1st year  $2\frac{1}{2}$  inches, entered the sea during the second year when 3 inches long, was already 9 inches long at the end of the 2nd year,  $19\frac{1}{2}$  inches long at the end of the 3rd year, and, as was known,

24½ inches at the time of capture near the end of the fourth summer.

The scale of a Sockeye, also taken at New Westminster in August, is shown in text-fig. 106. In the case of this fish, the entry into the sea seems to have coincided with the end of the first year's growth. That is to say, it was some time during the winter 1909-10. The readings from 20 scales show it to have been then 2¾ inches long. At the end of its second year it was 11¼ inches long, at the end of its third year 21¼ inches, and when captured 26½ inches.

The great difference in growth of the three fish in the second year is very noticeable, but it seems quite natural, and goes far to confirm the accuracy of my reading of the parr scale, when it is observed that the fish which appears to have spent the whole of its second year in the sea has grown most, and that the one which spent the longest part of it in fresh water has made the least progress.

It is further to be noticed that these fish all returned to spawn when of the same age, namely at the end of their fourth year. I have the scales of nine Sockeyes from the Fraser River. They varied in weight from 3¼ to 8½ lbs., but all are in their fourth year. In British Columbia the Sockeyes weigh from 3 to 10 lbs. Fish up to 17 lbs. have been caught, but over 10 lbs. they are very rare. I therefore seem to have got specimens of all the average weights. That they are all of the same age may be an accident, but much more probably it is not, and if it is not an accident it is a fact of the utmost importance to the Fraser River District.

In the Fraser River the run of Sockeyes in every fourth year, the year after leap year, is almost six times as large as in any of the intervening periods of three years, and this has been the case as long as records go back. Whether the fourth years have shot ahead of the others, or whether all years were once equal to them will never be known, but most likely adverse breeding seasons in the intermediate years have gradually diminished the stock. If it proves upon further examination of scales that every Sockeye returns to breed in its fourth year in this district, it might well be centuries before the breeding stock, once diminished, increased to its original numbers. British Columbia has now only one season out of four up to what might be the mark; and, if I am right, the inference is obvious that the efforts of the hatcheries should be devoted chiefly to the collection of ova in the lean years even if they have to import them from other districts. In the springs of 1906 and 1910, the years following the last two big years, 100,479,000 and 105,312,500 Sockeyes were liberated from British Columbian hatcheries. In the intermediate years the numbers were only 36,965,900; 51,855,200; and 41,909,500. My contention is, that if it is humanly possible the numbers hatched out in the seasons following the lean years should be made even greater than after the fat years. Some people may say, "But how do we know that if we turn out fry in the Fraser

River or its tributaries, they will return there when they grow up?" The very fact that it is in that district alone that three years out of every four are lean years shows that the fish return to their own river. If it were not so, the shortage in these years would have gradually spread itself over a wider area. It seems all the more wonderful that it has not done so, when it is remembered that the big shoal which comes in in the summer is by no means solely composed of fish making for the Fraser. The facts further appear to show that not only do the fish return to the Fraser,

Text-fig. 107.



Scale of Sockeye (*O. nerka*) removed after spawning.

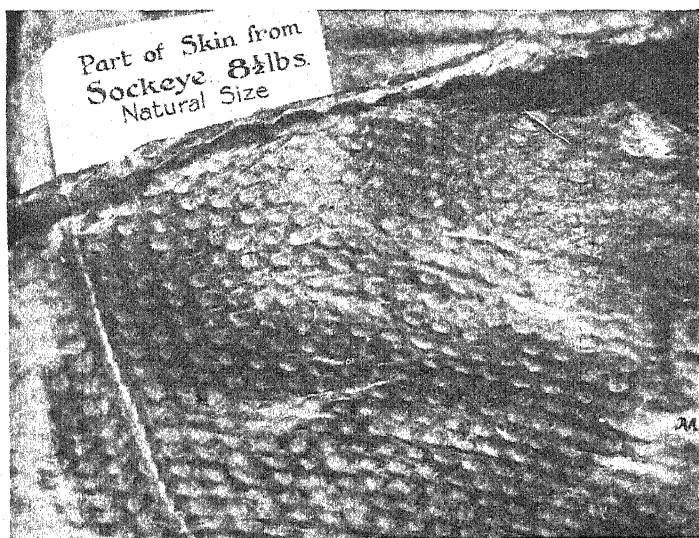
but to the very creek in which they were hatched, for how otherwise can one account for many of the creeks which are full of spawning fish in the big years being always absolutely untenanted in the years between them. Salmon marking in our own country has now shown almost conclusively that when the access to a river is unimpeded the salmon born in it invariably return to it. The fish that have been marked in one river and subsequently recaptured in another have all been from some



comparatively small stream, or from some river with a bad mouth which they might well find difficulty in entering again when they wished to do so.

The value of hatcheries is a much-disputed point on which I will not express any opinion. For the moment I am content to assume that they are of some value on the Fraser, and that being so, to point out how they can best be utilized. But I will say that if the falling off in the catches which has been apparent since about 1900, when each year is compared with the fourth year before it, proves to be more than a mere temporary fluctuation, hatcheries alone will certainly not remedy the evil, and it will be necessary for a time at any rate to restrict the number of fish that are permitted to be caught.

Text-fig. 108.



Piece of skin taken from a Sockeye (*O. nerka*) after spawning.

I should mention that I have scales from Sockeyes in their fifth year, but they came from the State of Washington, not from the Fraser.

In text-fig. 107 is shown the scale of a Sockeye which weighed  $6\frac{1}{4}$  lbs. and was caught at Morris Creek near Lake Shuswap, about 300 miles from the coast. So far as I can judge it is quite typical, and its interest is in showing, from the worn condition of its edge, that if a Sockeye ever returned to the sea after spawning and was caught again, a clear spawning mark should be apparent on its scales. The scales lie so far apart, and are so

flexible, that unless one saw how much they may become worn one would hardly believe it possible.

It will, I think, be news to most of those employed on the hatcheries that the spawning Sockeye possesses scales at all. Last year when I asked for scales from a hatchery, I was told that it was well known that the Sockeyes absorbed all their scales as food in the course of their run up the river and never had any when they reached the spawning beds. I argued the point, and the hatchery people ultimately sent me the piece of skin shown in text-fig. 108 taken from a Sockeye that had spawned, to convince me that I was wrong. The scales were there, but are by no means so clear in reality as they are in the photograph. They are very deeply imbedded in the skin, and, in order to remove some of them for examination, it was necessary first to soak it well and then to pull and stretch it so as to open the skin-pockets. After that the scales were still invisible and adhered closely to the skin which formed the top of the pockets. It was possible, however, to remove them with a pair of forceps without much further difficulty. So even those who have handled spawning Sockeyes for years may be excused for thinking them to be without scales.—How many fishermen in this country know that eels are covered with scales?

#### THE QUINNAT (*Oncorhynchus tshawytscha*).

The known range of the Quinnat on the American Coast is from the Ventura River in California to Norton Sound, Alaska. It probably really extends into Arctic regions. The Quinnat is also known as the Chinook Salmon, the King Salmon, the Tye, the Red or the White Spring Salmon, and the Black Salmon. The flesh is generally of a deep salmon-red colour, but in the south of Alaska and down to Puget Sound, sometimes as many as one-third of these fish have white flesh. Sometimes one half of the body is red and the other white, and sometimes the flesh is mottled. The white-fleshed fish are of little use. All the scales sent me and marked as from either Red or White Spring Salmon are from fish which have spent three winters, and a considerable part of the feeding season following the last winter, in the sea. Analogy from the true salmon would lead one to suppose that the white and mottled fleshed Quinnats might be fish that had spawned, but I can find no trace of a spawning mark on any of their scales. It has been suggested that the Red and White Spring Salmon are distinct varieties and that the specimens with mottled flesh are crosses, but upon this point I can offer no opinion. Differences in food might account for much, as in the case of the Brown Trout (*Salmo fario*).

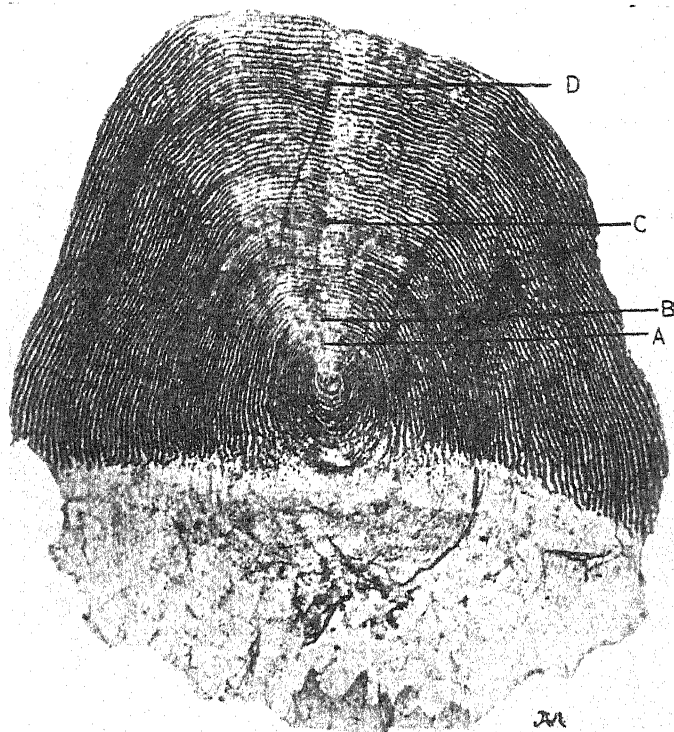
The name Black Salmon arises from the colour assumed by the Quinnat at spawning time.

In 1909 the weight of Quinnats canned on the Pacific Coast was 12,640,344 lbs.

As a rule Quinnats weigh from 18 to 30 lbs. in British Columbia, but much larger specimens are taken, and in Alaskan waters they have been caught over 100 lbs. in weight, and average 23 lbs. in some seasons.

Quinnats are very powerful swimmers and ascend fast-running streams in preference to others, making for the head waters, and sometimes running up for many hundreds of miles.

Text-fig. 109.



Scale of Quinmat (*Oncorhynchus tshawytscha*). 15 lbs. Length  $31\frac{1}{4}$  inches; girth  $19\frac{1}{2}$  inches. New Westminster, August 1912. (For references see text, p. 596.)

Most of the principal rivers have spring and autumn runs, and some of them a summer run also, so Quinnats may be said to run from January until October.

The scales I have examined show the running Quinnats to be in their fourth and fifth years, those over about 30 lbs. in weight being a year older than the others. Numbers of them are

spawned in the hatcheries, from which it was estimated that 90,740,472 were liberated in 1910.

I have already shown photographs from scales of Quinnats which weighed  $33\frac{1}{4}$  lbs. and  $62\frac{1}{2}$  lbs. (see text-figs. 95 and 96, pp. 574 & 575) and I now append another (text-fig. 109) from a fish which weighed 15 lbs. The parr or fingerling stage of each scale shows that the fish spent a year (A) and the greater part of a second year (B) in fresh water.

I have examined scales from eighteen Quinnats varying in weight from 10 to  $62\frac{1}{2}$  lbs., and all show about the same duration of the freshwater stage.

When the little fish enter the sea they seem to be already larger than the Sockeyes, and to measure from 4 to 6 inches in length. The lengths of the  $62\frac{1}{2}$  lb. fish at various ages, deduced from the measurement of eleven scales, were as follows:—At the end of the first year  $2\frac{3}{4}$  inches, when it entered the sea in its second year  $4\frac{1}{4}$  inches, at the end of the second year  $13\frac{1}{4}$  inches, at the end of the third year 25 inches, at the end of the fourth year 39 inches, and when captured it measured  $50\frac{3}{4}$  inches. The scale illustrated (text-fig. 96) agrees exactly with these averages up to the end of the third year, but the position of the fourth winter band on it would show the fish to have been about 40 inches long at that time instead of 39 inches, if that scale alone were to be depended upon.

The lengths of the 15 lb. fish, as shown from 22 scales, were, at the end of its first year  $3\frac{1}{2}$  inches, when it entered the sea  $5\frac{1}{4}$  inches, at the end of its second year  $13\frac{3}{4}$  inches, at the end of its third year 26 inches, and when captured it measured  $31\frac{3}{4}$  inches. Text-fig. 109 shows the points from which the measurements were taken, the scale being exactly an average one.

The measurements of the  $33\frac{1}{4}$  lb. fish, averaged from 16 scales, were, at one year  $3\frac{1}{4}$  inches, when it entered the sea  $4\frac{3}{4}$  inches, at the end of the second year  $12\frac{1}{4}$  inches, at 3 years  $21\frac{3}{4}$  inches, at 4 years 31 inches, and when captured  $41\frac{1}{2}$  inches.

The above seem to be about the average lengths of Quinnats at the ages given. None of the twelve specimens I have measured depart far from them.\*

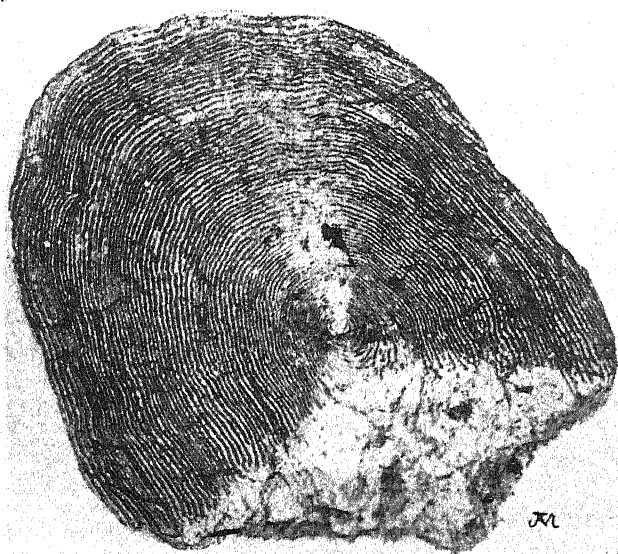
### *The Spawning Mark.*

On the scale of the  $33\frac{1}{4}$  lb. Quinнат (text-fig. 95, p. 574), a check in growth (S) may be observed beyond the fourth winter band (E). It is equally clear on every scale of this fish, and I think it must be a spawning mark. One might expect

\* Note:—Since this paper was written I have ascertained that in the Natural History Museum, South Kensington, there are specimens of Quinнат parr, about 4 inches in length, which came from a lake near the head waters of the Fraser River. I have had the privilege of examining the scales of one of these specimens which measured about  $4\frac{1}{4}$  inches. The first winter band is quite clear, and five lines formed in the second summer are apparent.

a better defined scar, but Quinнат scales are very thin and flexible, and besides are well protected by a great thickening of the outer skin at spawning time, so they may never become much worn at the edges. That they may not have become much worn up to the actual time of spawning is shown by text-fig. 110, a photograph of a scale removed from a 12 lb. Quinнат *after* it had spawned in the South Thomson River, about 300 miles from the sea. That scale not only sustained the wear from the shrinkage of the fish owing to lost condition between the time at which it left off feeding, which the lines following the last winter band

Text-fig. 110.



Scale of 12 lb. Quinнат (*O. tshawytscha*) from South Thomson River.

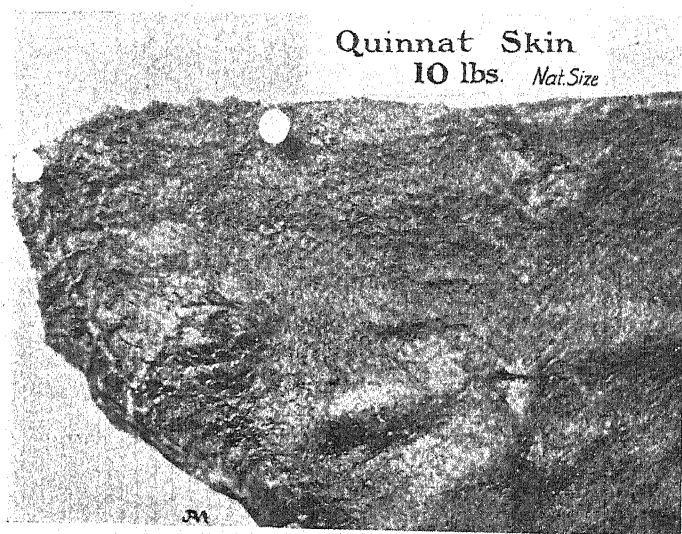
Fish speared after spawning, 13th October, 1911.

show to have been quite early in the year, until it was speared for me under the supervision of Mr. John Brown of Celista, B.C., on the night of 13th October, 1911; but the skin was sent to me dried and folded, and I removed the scales from it myself. As this scale shows so little sign of wear at the edge, it seems to me quite conceivable that the mark *S* on text-fig. 95 is a spawning mark. If it is not, I am unable to suggest any other explanation of it.

Compare text-fig. 95 with text-fig. 109. These scales were taken from fish caught at the same place at the same time. There are more lines after the last winter ring on the former than on

the latter, and that in spite of what is a very obvious check in growth. The check clearly lasted long enough for the edges of the scales to become somewhat worn, for the lines following it do not at all points exactly follow the contours of those immediately preceding them. This fish cannot in these circumstances have grown faster than its fellow, which was feeding all the time, and yet there are 20 lines as against 12. If, however, it spawned it added the twelve lines between the winter band and the scar in the early part of the year 1911, and the eight lines outside the scar in 1912. It would have spent the early part of 1911 in the sea, then come in to fresh water to spawn, and remained there after spawning for some little time. It would then have returned to the sea in poor condition and possibly not very early in 1912, so that by the time it had made up condition and started to grow again it would add but another 8 lines or so to its scales before the spawning instinct again induced it to seek fresh water, and thus brought it to the place of its capture.

Text-fig. 111.



Piece of skin taken from a Quinнат (*O. tshawytscha*) after spawning.

Compare this mark also with the outer spawning mark on text-fig. 101, and note how like they are.

A Quinнат of about 30 lbs. is just the size on which I think a spawning mark is most likely to be found. The larger fish, like the 62½ pounder, a scale of which is shown in text-fig. 96, have most probably attained their size on account of the feeding

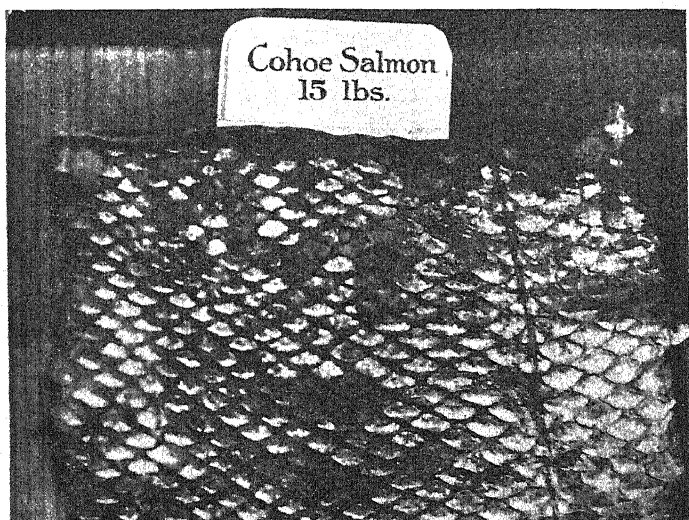
instinct being more pronounced than the sexual. Scale reading, so far as it has gone, has shown that our own very large salmon are all maiden fish.

Text-fig. 111 shows a piece of Quinnat skin taken from a fish that had lately spawned.

#### THE COHOE (*Oncorhynchus kisutch*).

The salmon with which I shall next deal is the Cohoe, also known as the Silver Salmon and the Fall Salmon. The photograph of its skin (text-fig. 112) shows that the scales overlap much more than those of either of the species already described. A spawning mark should therefore be better defined if one were to be found.

Text-fig. 112.



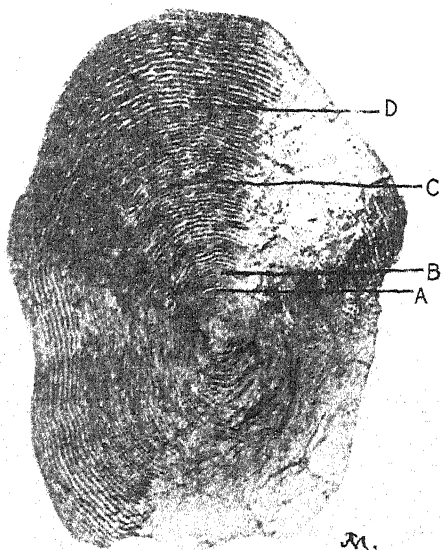
Piece of skin of the Cohoe (*Oncorhynchus kisutch*).

The Cohoe Salmon gets the name of "silver" salmon from its appearance when it first comes in from the sea. It is then a most brilliant silver with a greenish tint on the back. As spawning time approaches it becomes a dirty red. The Cohoe is found in almost all the Pacific Coast streams from Monterey Bay northwards. The run in the Fraser River is in September and October, but the Cohoes are on the coast from July to November. The weight of Cohoes canned in 1909 was 17,789,890 lbs., but large numbers, 1,152,452 lbs. in United States waters alone, were dealt with in other ways. The Cohoes in British Columbia weigh usually from 3 to 8 lbs., but larger specimens are by no

means uncommon and may weigh as much as 30 lbs. More Cohoes would probably be canned if the run did not occur so late in the year, at a time when most of the canning stations are closed for the winter.

The number liberated from the hatcheries in 1910 was 50,424,386, but in some years the numbers have been much greater.

Text-fig. 113.



Scale of Cohoe (*O. kisutch*), ♀. 5 lbs. 6 oz. 17th November, 1911.

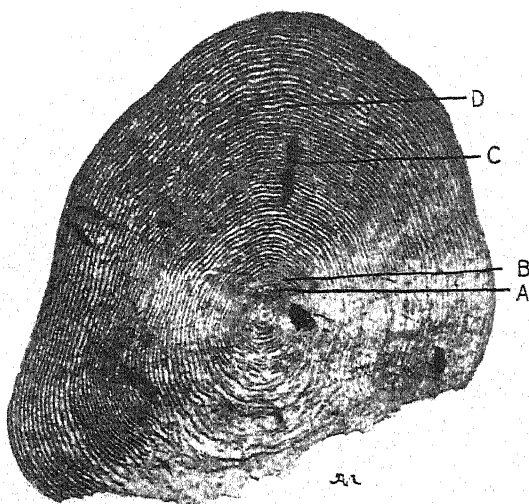
I find the scales of the Cohoes the most difficult of all to read. I have specimens of scales from eighteen fish from Puget Sound and from Shuswap, on the Fraser River. These fish varied in weight from 3 to 18 lbs. What strikes one as most curious is that, with the possible exception of one fish of 5 lbs. 6 oz. (text-fig. 113) in which a few close lines between B and C, which I think due to a slight check in feeding, may really be the second winter band, their scales show them all to have been of the same age, namely nearing the end of their fourth year.

I am satisfied that the Cohoes spend the whole of their first year in fresh water. At the end of it they measure, according to their scales, from  $2\frac{1}{2}$  to 3 inches. One rapid grower, which weighed 15 lbs. near the end of its fourth year, measured as much as 4 inches at the time of migration. The growth in the



second year is very difficult to make out. I feel convinced that the greater part of it (I mean as to time) has taken place in fresh water in nearly every instance, and in no instance am I quite convinced that the whole of it did not do so. If the whole of the second year's growth took place in fresh water, the fish are a year older than I have stated above. In all cases (I speak, of course, only of the fish I have examined) the first entry into the sea appears to have taken place between 18 months and 2 years after hatching. Further certainty is added to this statement by the measurements of the scales, which show the second year's growth to have been comparatively small. In three instances in which, from the arrangement of the rings, I think the fingerlings entered the sea when about 18 months old, the little fish were three times as long at the end of their second year as at the end of their first. None of the others even quite doubled their length. That is what one would expect at that stage from fresh-water feeding, but not from sea food. In the third year growth is very rapid, and hardly diminishes even as winter comes on.

Text-fig. 114.

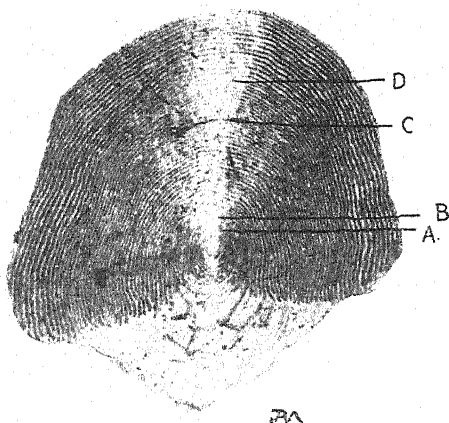
Scale of Cohoe (*O. kisutch*), ♂. 14 lbs. Puget Sound, 18th October, 1911.

Text-figs. 114 and 115 are typical Cohoe scales.

All the scales from Puget Sound are from fish captured on 18th October, 1911, and all show at their edges the lines coming close together to form the next winter band, see text-fig. 114. A similar formation may be noted on text-fig. 113, which reached

its spawning ground a month later. But compare these scales with text-fig. 115. This fish was forwarded to me from Toronto on October 17th, so that it must have been procured at Lake Shuswap some days earlier.

Text-fig. 115.



Scale of Coho (*O. kisutch*), ♀.  $3\frac{1}{4}$  lbs. Shuswap Lake.  
Weighed after spawning.

According to Dr. Greene (Migration of Salmon in Columbia River, Bulletin of U.S. Bureau of Fisheries, vol. xxix. 1909), a Silver Salmon travels about 7 miles *per diem*. This fish, then, to reach Shuswap by, say, October 12th, must have ceased feeding in the sea not later than 23rd August. It will be noticed that the outer lines of the scale are still widely spaced, showing that summer feeding and growth were still in progress up to the time at which the fish left the sea for the river.

#### THE HUMPBACK SALMON (*Oncorhynchus gorbuscha*).

I have but little to say at present about the Humpback, the Dog Salmon, and the Steelhead Trout.

The Humpback has flesh of a pale pink colour. It was not used for canning purposes until quite lately, but now there is a good trade in it with China and Japan, where it is much esteemed. The Chinese, not being accustomed to red-fleshed fish, were very shy of the canned Quinns and Sockeyes when I was in China in 1893, and this may account for their partiality to the Humpback.

The total weight of Humpbacks canned on the Pacific Coast in 1909 was 100,326,144 lbs., and over another 3,000,000 lbs. weight was used in other ways.

Humpbacks were first dealt with in the hatcheries in 1904, and since then have been turned out from them intermittently, but never in very large numbers, comparatively speaking.

They take their name from a peculiar hump which appears behind the heads of the males at spawning time. They are from 3 to 11 lbs. in weight, and have very small scales.

The main run is in Alaska. South of Puget Sound the Humpback is almost unknown. In the Fraser River the runs in the big Sockeye years and in the years next but one after them are much larger than in the other years. The fish, however,

Text-fig. 116.



Scale of Humpback Salmon (*O. gorbuscha*), from Puget Sound.  
(For reference see text, p. 604.)

seem to come in at various ages, so this state of affairs will probably gradually right itself again if the netting is not too severe. I am judging from possibly but a few specimens. A large number of Humpback scales have been sent me, but, unfortunately, with no further information than that they were taken from Humpbacks in Puget Sound on their way to the Fraser River. I append a photograph (text-fig. 116) of one of these scales. The centre is only moderately well defined, but in all the others it is even less clear, so that I have not been able to

form any definite opinion as to the time spent in fresh water. This scale shows clearly one winter band formed in the sea (AA). I presume that it represents the growth of the second winter. All the scales show a similar band, and many of them another evidently formed a year later.

I can give no measurements as I do not know the length, or even the weight, of any of the fish when caught.

### THE DOG SALMON (*Oncorhynchus keta*).

The Dog Salmon frequents the Pacific Coast all the way from San Francisco to the Arctic Circle, but is most plentiful between Puget Sound and South-East Alaska. This fish is also called the Chum Salmon, and is known in Japan as Sake, and in Siberia as Kita.

I have not before referred to the prevalence of any of the species on the other side of the Pacific, and only do so now because the Dog Salmon has long been a staple food of Japan, and it is because this fish is white-fleshed, or almost white, that the red colour of the other varieties has caused them to be viewed with suspicion when exported to the East. This fact was ascertained by me when I was in China and Japan in 1893.

The Dog Salmon gets that name from the distorted appearance of the mouth of the males at spawning time. They then look not unlike snarling dogs. The average weight of the Dog Salmon is about 8 lbs. In British Columbia it is higher, from 10 to 12 lbs. 16 lbs. would be about the maximum weight.

The weight canned in 1909 was 25,660,845 lbs., and over 4,000,000 lbs. weight was otherwise dealt with for export.

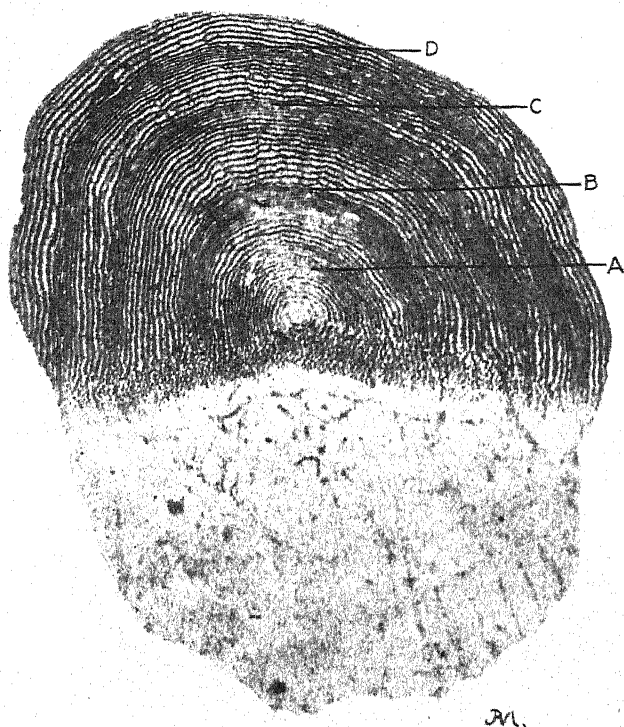
It is only in Washington State that these fish have been spawned in the hatcheries. There an average of about 7,000,000 fry have been turned out in recent years beginning with the year 1900.

As a general rule the Dog Salmon comes in late in the year, September to November. But in Alaska the run begins in June, and in the Fraser River in the middle of August.

In British Columbia they spawn close to the sea. This I had gathered from the appearance of the scales before I found out that it was known to be the case. I have received scales from two specimens weighing  $11\frac{1}{2}$  and 12 lbs. respectively, both caught in Puget Sound on their way to the Fraser River. They show no indication of fresh water feeding at all. The fry evidently descend to the sea as soon as hatched out. The measurements of 10 scales of the  $11\frac{1}{2}$  lbs. fish, one of which is shown in text-fig. 117, enable me to give the rate of growth as follows:—At the end of the first year  $7\frac{1}{4}$  inches, at two years 13 inches, at three years 22 inches, at four years  $27\frac{1}{2}$  inches, and when caught in its fifth year it measured 31 inches. Its capture was evidently

an early one, as the summer growth is only just complete. Unfortunately I have not got the date. The 12 lbs. fish was caught at the same time and place. It was shorter,  $30\frac{3}{4}$  inches, but thicker, 17 inches. Its length at the end of each winter was  $5\frac{1}{4}$ , 11,  $20\frac{1}{2}$ , and  $26\frac{1}{2}$  inches. From a smaller beginning it was steadily overtaking the other fish in length, and had already done so in weight when caught.

Text-fig. 117.



Scale of Dog Salmon (*Oncorhynchus keta*). ♀.  $11\frac{1}{2}$  lbs.  
Length 31 inches; girth  $16\frac{3}{4}$  inches.

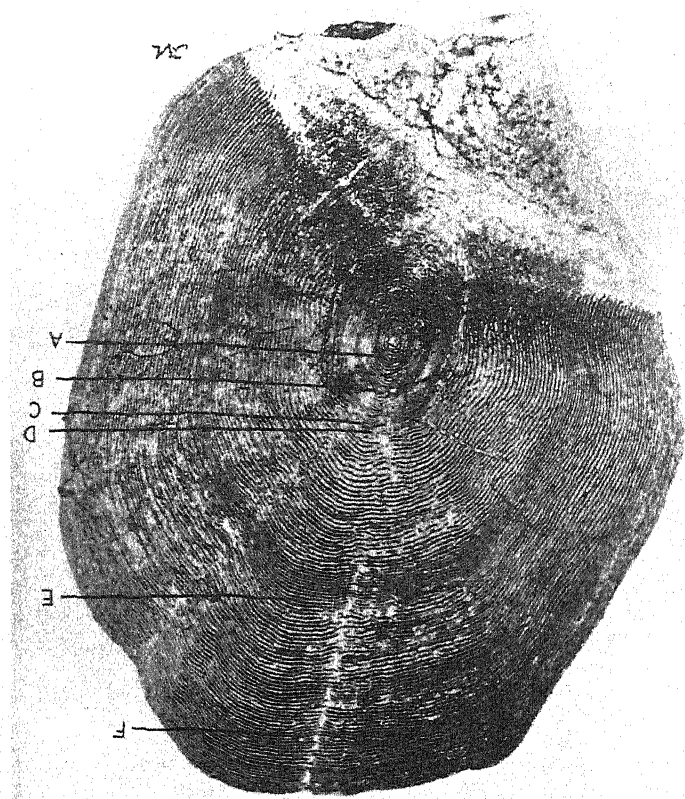
#### THE STEELHEAD TROUT (*Salmo gairdneri*).

The last of the Pacific Coast salmon with which I am dealing is the Steelhead, which is there called a trout, but is the only Pacific member of the sub-genus *Salmo*, to which the true salmon belongs. It is believed to be a migratory form of the Rainbow

Trout. The flesh is pale-coloured, and is not much used for canning.

The Steelhead is found from Carmel River, California, northwards to Central Alaska. In California it may be fished for only with hook and line. In 1909 4,229,704 lbs. weight was canned and 1,960,000 lbs. weight was otherwise used in the United States fisheries, without counting those frozen or salted in British Columbia.

Text-fig. 118.



Scale of Steelhead Trout (*Salmo gairdneri*), ♂. 12 $\frac{3}{4}$  lbs. Length 33 inches; girth 16 $\frac{1}{2}$  inches. New Westminster. Autumn, 1912. (For references see text, p. 607.)

In 1910 there were liberated by the U.S. hatcheries 12,023,646, but none was turned out in Canada.

The spawning season is in the spring, but Steelheads are to be

found in fresh water at most seasons of the year. They weigh, on an average, at different places from 8 to 15 lbs., with a maximum of about 45 lbs.

The scales, of which I have specimens from several fish, but from only two that had been weighed and measured, show that life in fresh water before the first migration to the sea may be of considerable duration. In this species, as in the case of our own salmon, no doubt is possible as to the limits of the part of the scale formed in fresh water. From examination of a large number of scales from my two measured fish, I judge them to be about 7 inches long when they enter the sea. As spawning takes place in the spring, the number of lines on the scale at the end of the first winter is naturally very small. The scale illustrated in text-fig. 118 shows five up to the point A, and that seems the usual number, but the first band is not always visible on all the scales, which is not to be wondered at seeing how minute they are,  $\frac{1}{10}$  inch long at the most, at that time.

A second winter in fresh water is shown in text-fig. 118 by the band B, and a third by the band C. Outside of it are two or three more lines added to the parr scale in the fish's fourth year, before it entered the sea. All the Steelhead scales which I possess show similar lines and bands, so I suppose one may take it that these fish remain in fresh water until well on in their fourth spring, counting that in which they were spawned as one. They would then be just three years old.

When they get to the sea they grow very rapidly. The first band completed in the sea within a year of migration shows my two measured fish to have been then already from  $19\frac{1}{2}$  to  $20\frac{1}{2}$  inches long (see text-fig. 118, E), and the second winter band shows a length of from 29 to  $30\frac{1}{2}$  inches (text-fig. 118, F), but I am not sure that I have identified this band correctly on the scale illustrated. These two fish were both caught near the mouth of the Fraser River in the autumn of 1912, when they measured  $31\frac{3}{4}$  and 33 inches respectively and weighed  $12\frac{3}{4}$  and 13 lbs., the shorter and thicker fish being a female. They had then done a considerable amount of feeding in their sixth year.

This completes for the present my review of the salmon of the Pacific Coast of North America.

It must always be borne in mind that my observations have been made on the scales of fish from the Fraser River district alone, and that readings from the scales of salmon caught elsewhere might show considerable differences. Some divergence is almost certain in the duration of freshwater life, for observations of the scales of the true salmon (*Salmo salar*) have shown that the further north one goes the longer does the young salmon remain in fresh water, and it is not at all unlikely that the Pacific salmon are influenced in the same way by climatic conditions.

The strongest argument which I have heard in favour of the prevailing idea that Pacific salmon migrate to the sea as soon as they can swim, is that many of the rivers which they frequent are small, and, at times, are either dried up or frozen hard. This argument was put before me by a gentleman who is largely interested in the Pacific Coast fisheries and generally recognized as an authority thereon. It therefore seems to demand an answer. My answer is that I have examined only the scales of fish hatched in the large watershed of the Fraser River, and that possibly the fry of the Pacific salmon can adapt themselves to varying conditions. It is known that our own salmon, which generally migrate to the sea at two years of age, may enter it at one year without hurt, or may remain in fresh water for three, four, or even five years where the circumstances, as in Norway, make it desirable for them to do so.

But, even supposing that they can adapt themselves to a certain extent, I fail to see how any salmon can perpetuate its species in a river which is frozen absolutely solid in winter, or which is bone-dry in summer. In fact, I believe that the fish that run into small rivers where such conditions prevail have not been hatched in them at all, but are really natives of one or other of the large river systems, and that, when they get into one of these small rivers, they become at once of no further use to their own species, and might as well all be promptly utilized as food for the good of ours.

For a fact which supports this belief I have only to refer to what Mr. W. L. Calderwood says in a communication to the 'Salmon and Trout Magazine' for December 1912, page 24. He there describes Capt. Callbreath's hatchery in Alaska. I am not now concerned with the hatchery itself, but with the fact that it is on a river, the Jadeska, only half a mile long, which runs out of a small lake. A dam has been thrown across the river, only 100 yards from the mouth, so as to intercept all fish, and enable the operators to select the Sockeyes and refuse the other salmon. In addition to this dam a fence of racks has been erected having at one place a trap. Here the Sockeyes have been taken out and lifted over the dam, if not required for the hatchery, while the other species have been left below. This selection has gone on for eighteen years, and still continues, although the Sockeye hatchery was a failure and hatching operations were discontinued in 1906. Mr. Calderwood says:—"It is an interesting point that, although the natural and artificial propagation of the Humpback and Dog Salmon were entirely discouraged, the number of these fish continued apparently undiminished." He adds, and this is my point, "The moral may be that the fish in this river, like the fish in other small rivers, are largely drawn from other sources." But, in this case, as none but Sockeyes have been admitted to breed, it would seem proper to substitute the word "entirely" for the word "largely," and I submit that what applies to one small river may equally well apply to them all.



If the perusal of what I have written induces others to pursue this fascinating study of scales upon the lines I have suggested, my work will have served its chief purpose.

That the study is a most important one cannot be denied. The salmon fisheries of the Pacific Coast are a source of vast wealth to the countries so fortunate as to share in them. But that source of wealth, like our own salmon fisheries, already shows signs of having been too lavishly drawn upon. It is easy to kill the goose that lays the golden egg. By legislation much may be done to prolong its life, but legislation can effect its purpose only if based upon thorough knowledge. In this country, if salmon scales had been studied before the Acts which regulate our fisheries had been passed, these Acts would have been very different from what they are. The study of scales has so revolutionized our knowledge that, of the eleven facts in the life of the salmon, mentioned by Mr. Cholmondeley Pennell in 1886 as *absolutely* proved, one, the most important, has now been shown to be absolutely wrong, and two others, hardly less important, require much modification.

I have not made myself familiar with the various fishery laws and regulations of the Pacific Coast, but I know that many experts think them insufficient. If the regulations as to netting are to be made more stringent, let it be done with as complete knowledge of the various salmon as possible; and in order that that knowledge may be obtained let their scales be systematically studied. For months, or years, the fish are hidden from our eyes, but from their scales we can fill in the gaps while they are out of view, for it has been well said that every salmon carries a record of its life on each of its scales. Whether I have read the records written on the scales of the Fraser River salmon correctly or not, I can at least claim to have proved that the records are there.

In conclusion, I have to thank Mr. W. J. Sim of Northville, Kings Co., Nova Scotia, for much valuable information, and for having procured me numerous specimens through his friends Mr. Frank Parry, now also of Northville and formerly of Granite Creek, Mr. J. Brown of Celista, B.C., and Mr. Josephson of Bellingham, Washington, U.S.A., and Mr. J. Kirkpatrick of Vancouver. The various statistics I have given have been compiled mainly from "The Salmon Fisheries of the Pacific Coast," by J. N. Cobb, Bureau of Fisheries, Document 751, Washington, 1911, and partly also from the Report of the Commission of Conservation on "Lands, Fisheries and Game, and Minerals," Ottawa, 1911.

The following table may prove of interest :—

CHARACTERISTICS.		Sockeye, <i>O. nerka</i> .	Quinnat, <i>O. tshawytscha</i> .	Coho, <i>O. kisutch</i> .	Humpback, <i>O. gorbuscha</i> .	Dog Salmon, <i>O. keta</i> .	Steelhead Trout, <i>S. gairdneri</i> .
Note.—This is a copy of the table published by Mr. G. A. Boulenger, F.R.S., in 'Country Life' for April 23rd, 1910.	Number of gill-rakers on the anterior arch . . .	32-40	20-28	20-25	28-36	20-25	
	Number of well-developed rays in anal fin.	14-15	15-18	12-14	15-16	13-14	10-12
	Number of scales on lateral line . . . . .	125-135	140-155	125-135	150-170	135-145	
	Number of lines of scales between lateral line and dorsal fin . . . . .	20	25	25	30	25	
Number of pounds canned, pickled, frozen, or salted on the Pacific Coast in 1909, in millions of pounds—nearest million . . . . .		215	13	19	103	30	6
Number of fish caught in 1909, calculated from total weight as given above, and general average weight in millions, after allowing one-fifth for waste . . . . .		54	$\frac{3}{4}$	5	31	5	$\frac{3}{2}$
Number of fish liberated from the hatcheries in 1910 in millions—nearest million . . . . .		316	91	50	2	7	12
Average weight of fish, as caught, in pounds . . . . .		3-10	18-30	3-8	4	8-12	8-15
Maximum weight attained, in pounds, about . . . . .		17	100	30	11	16	45
Approximate time spent in fresh water before migration to the sea, in Fraser River district, in months . . . . .		12-15	18	18-24	?	3 or less	36
Approximate length at time of migration to the sea, in Fraser River district, in inches . . . . .		3-3 $\frac{1}{2}$	4-5 $\frac{1}{2}$	2 $\frac{1}{2}$ -5	?	1 $\frac{1}{2}$ or less	7
Age at time of return to fresh water, in Fraser River district, in years; as shown by my specimens . . . . .		2 $\frac{3}{4}$	3 $\frac{3}{4}$ -4 $\frac{3}{4}$	3 $\frac{3}{4}$	2 $\frac{1}{2}$ -3 $\frac{3}{4}$	4 $\frac{3}{4}$	5 $\frac{1}{4}$

38. Notes on *Peripatoides woodwardi* Bouvier.

By KATHLEEN HADDON\*.

[Received April 11, 1913: Read May 6, 1913.]

This species has been described by Prof. Bouvier†. It may readily be distinguished from other Australian species by the fact that it has 16 pairs of legs; in this respect this species and *P. suteri* from New Zealand are unique among all the Australasian *Peripatoides*.

The material was obtained through Prof. J. Stanley Gardiner, from Western Australia.

There are twenty specimens, well preserved and extended, but they tend to be rather bent, thus making exact measurement difficult. The approximate measurements (in millimetres) are as follows:—

Females ...	46, 43, 43, 41, 37, 37, 33, 23, 21, 17.
Males .....	31, 30, 30, 29, 27, 24, 24, 24, 23, 22.

It will be seen, therefore, that these specimens are considerably larger than those described by Prof. Bouvier‡, the greater number of which measured from 10·5 to 17 mm., only one reaching the length of 21 mm.

Bouvier recognises the following types of coloration:—

1. Uniform, with predominance of blue-green pigment, yellowish pigment being strewn in spots equally distributed over the dorsal surface.
2. Striped, with the yellow spots more numerous, sometimes becoming predominant, and forming a longitudinal band, with or without dark papillæ, on each flank above the base of the legs.

A variation of the first type had the ground colour light reddish yellow, almost all the papillæ being darker, at any rate at the summit; some were quite black and arranged in short transverse rows. Thus the general tone was a dingy grey-black with small spots of yellowish pigment round some papillæ.

A variation of the second type showed a yellow-red ground colour, with stripes of dark papillæ in transverse rows in the dorsal region and no mixture of dark pigment in the lateral stripe.

All his specimens showed two large light-coloured papillæ on the flanks between each pair of legs, arranged parallel to the long axis of the animal.

These types are all represented in my specimens and also all

\* Communicated by Prof. J. STANLEY GARDINER, M.A., F.R.S., F.Z.S.

† 'Die Fauna Südwest-Australiens,' Bd. ii. No. 18, Onychophora. M. E.-L. Bouvier. Jena, 1909.

‡ *Loc. cit.* p. 315.

the intermediate stages between them. Those belonging to the first type show in addition a well-marked lateral stripe of a greenish-blue colour. The antennæ are also of a greenish-blue, thus differing from those of Prof. Bouvier's specimens which he describes as always being black. Four of the animals are very dark in colour, one being practically black, but all have a brownish-green tinge; the ventral surface is lighter, but even then darker than the backs of the other specimens. The darkest specimen, which is a male, differs from all the others in having the crural papillæ black instead of white. All the animals show a patch of green pigment on the inner side of each leg which is extended on to the ventral surface of the body. In most cases the ventral and pre-ventral organs are not well-marked, but some of the smaller specimens show the ventral organs distinctly. The two light coloured papillæ described by Prof. Bouvier as situated between each pair of legs are not apparent in these specimens.

The coloration of these *Peripatus* agrees fairly closely with that of *Peripatoides orientalis*\*, except that the dark variety is by far the most common in the last-named species (77½ per cent. according to Steel†), whereas in *P. woodwardi* they are in the minority, as far as our present material goes.

With regard to the external features, these specimens of *P. woodwardi* agree with those described by Prof. Bouvier‡ in every respect except for the number of crural papillæ in the male. These are very prominent and capable of retraction within the leg, and he describes them as present on all the legs with the possible exception of the 15th and 16th, that is the last two pairs, while he found coxal glands in all the legs except possibly the 15th pair.

I have examined all the males in my material, and although the papillæ show extremely clearly in most cases, I can find no traces of them on the 4th or 5th legs; they appear to be entirely absent from these legs, as well as from the 15th; the last pair of legs may show a small papilla. In the male that I dissected the coxal glands showed very clearly in the other legs, but no trace appeared in the 4th, 5th, or 15th pairs. The absence of these glands in the 4th and 5th pairs of legs seems to be correlated with the great development of their nephridia, which open by a urinary papilla on the proximal of the three spinous pads of the foot.

As described by Prof. Bouvier, the first pair of crural glands are extremely long and lie in the lateral sinus with the nephridia; the last pair are elongated and iridescent and lie in the lateral sinus or in the general cavity of the body, while the remaining

\* "Monographie des Onychophores." E.-L. Bouvier. Ann. des Sc. Nat. vol. v. 9th series, 1907, p. 233.

† "Observations on *Peripatus*," Proc. Linn. Soc. N. S. Wales (2) vol. xxi. 1896, p. 94.

‡ "Die Fauna Südwest-Australiens," p. 320.

ones are of the same type as those of *P. orientalis*, a vesicular gland with a narrow duct lying in the leg.

The only other particular in which my specimens differ from those of Prof. Bouvier is in respect to the female generative organs. In the two examples that he dissected there was little or no trace of a receptaculum seminis, but he points out that the ovaries were very large, thus making the dissection difficult.

In both the females that I dissected it was easy to trace the oviducts for the whole of their course, and shortly after their emergence from the ovarian sac, where they at once diverge from one another, there was a well-marked receptaculum seminis on each side, full of sperm. This is another point of resemblance between this species and *P. orientalis*, which seems on the whole to be the most nearly related form.

### 39. Field-Observations on the Enemies of Butterflies in Ceylon. By J. C. F. FRYER, M.A., F.E.S.; Fellow of Gonville and Caius College, Balfour Student in the University of Cambridge.\*

[Received April 22, 1913; Read May 6, 1913.]

#### ETHOLOGY (BIRDS AND BUTTERFLIES).

The subject of Birds and Butterflies in Ceylon has already been admirably dealt with by Col. N. Manders in his paper entitled "An Investigation into the Validity of Müllerian and other forms of Mimicry, with special reference to the Islands of Bourbon, Mauritius, and Ceylon"†. In spite of this, however, I venture to place on record a few further notes from the island, partly because they deal more fully with the butterfly-eating habits of a most interesting bird, the Wood-Swallow (*Artamus fuscus* Vieill.), but also because the subject, with its direct bearing on the various theories of mimicry, is essentially one which requires as many observations as possible before any fair generalisations can be made.

A residence of a year and nine months, largely devoted to entomological research, gave an opportunity for keeping a continual watch on certain of the more common insectivorous birds; and the following notes comprise every observation made during that period. The locality in each case, unless otherwise stated, is the celebrated Botanical Garden at Peradeniya‡. Other localities mentioned are Vavonia-Valunkulam, Maha Illupalama, and Trincomalee—all places in the hot dry northern country, which is characterised by the large area of jungle it contains,

\* Communicated by Prof. J. STANLEY GARDINER, M.A., F.R.S., F.Z.S.

† Proc. Zool. Soc. 1911, p. 696.

‡ Elevation about 1600 feet.

and also, in my experience, by a greater quantity of butterflies and other insect life than can usually be found in the hills.

The notes are given in chronological order, and are extracted from my journal practically without alteration, as this method, though possibly wearisome, places a check on the personal prejudices of the observer, the introduction of which it is difficult to avoid in a mere summary of results.

#### PERADENIYA.

1911. *April 7th.* A drongo\* took a *Papilio polytes* Linn. ♂, which could hardly fly, as it had only just emerged; it then caught a *Melanitis ismene* Cram., also released soon after it had left the pupa.

*April 2nd-9th.* General note that "drongos were only observed to take small butterflies, chiefly *Ypthima ceylonica* Hewit., Lycænids, and occasionally *Precis iphita* Cram." "Of the various attempts quite one out of two missed their object, while in many cases the swoop at a butterfly seemed to be taken more for amusement than to gain food." "Paradise fly-catchers (*Terpsephone paradisi* Linn.) being more retiring, were harder to observe; they certainly took *Ypthima ceylonica* and small Lycænids, but were not observed to attack anything large." [This week, April 2nd-9th, was spent mainly in bird observations, and the above is the result.]

*April 15th.* A drongo was seen to attack *Catopsilia pyranthe* Linn., but apparently without success.

*May 9th.* A drongo was seen to take an *Ypthima ceylonica* in the garden. . . . Three drongos chased a *Papilio parinda* Moore, but did not catch it. . . . Two bulbuls (*Molpastes haemorrhous* Gm.) chased an orange-coloured moth, probably *Argina* sp., but lost it.

*June 25th.* A Paradise fly-catcher swooped at a *Limnitis calidasa* Moore, which escaped.

*July 9th.* A magpie-robin (*Copsychus saularis* Linn.) took a specimen of the Chalcosiid moth, *Heterusia cingala* Moore †, and flew away with it.

*October 16th.* A drongo chased a *Papilio parinda*, but lost it.

*October 19th.* A drongo caught a *Papilio polytes* ♂, and ate it.

*October 21st.* A scanty *P. polytes* migration for the last three days. . . . A drongo swooped at a *P. polytes* ♀ form *polytes* ‡, but missed it. Many females of the *romulus* form § with the entire hinder portion of the hind wings missing.

*November 1st-15th* (at Vavonia-Valunkulam). A continual migration of *Appias* (*A. paulina* Cram. and *A. albina* Bois.),

\* Throughout, the word "drongo" is used for either *Dicrurus leucopygialis* Blyth, or *D. caerulescens* Linn. The former was more common; but the species in most cases was not ascertained.

† This should undoubtedly be an "inedible" species, as it has all the Chalcosiid's nauseous characters to a marked degree.

‡ *P. polytes* ♀ *polytes* resembles *Papilio aristolochiae* Fabr.

§ *P. polytes* ♀ *romulus* resembles *Papilio hector* Linn. Both *P. aristolochiae* and *P. hector* are common Ceylon insects.

*Catopsilia* (*C. crocale* Cram. with a few *C. pyranthe* Linn.), *Papilio polytes*, *P. jason* Linn., *P. nomius* Esper, and *P. hector* Linn. Bee-eaters (*Merops* sp.?) were common, but were only observed to chase butterflies (*P. jason*, *Appias* sp.) on three occasions, each attempt being unsuccessful. Wings of all the above butterflies were found occasionally along the roads, but not in any number.

November 25th (at Peradeniya). A drongo seen to take a *Papilio polytes* ♀ *romulus*, which was flying badly.

November 29th. A number of wings of *Euplœa* and *Danaïs* found on the ground in the garden. The only birds seen near were wood-swallows (*Artamus fuscus* Vieill.). The wings identified were:—*Euplœa core* Cram., fore wings 6; *E. kollari* Feld., fore wings 2; *E. coreta* God., fore wing 1; *Danaïs septentrionalis* Butl., fore wings 5, hind wings 3.

November 30th. Spent an hour, 11 A.M.—12, watching the wood-swallows hawking butterflies, which appeared to be forming their sole food. The birds sat on the top branches of a leafless tree, and swooped out after their prey, usually effecting a capture. The successful attempts were estimated at two out of three. The butterfly was carried to the perch and the wings there discarded. Butterflies on migration were extremely abundant, and individuals of the genus *Catopsilia* were perhaps most numerous, though *Euplœas*, *Danaïds*, *Papilio polytes* and *P. demoleus* Linn. were all quite common. The wood-swallows limited themselves almost entirely to *Euplœas* and *Danaïds*, only three swoops at *Catopsilia* and one at *Papilio demoleus* being observed, and these were all failures. The majority of the discarded wings were blown into the river, but the following were collected, practically all of which must have fallen during the morning.

Result:—*Danaïs septentrionalis*: fore wings 61, hind wings 9.

*Euplœa core*: fore wings 48.

*E. coreta*:       "       "       29.

*E. kollari*:       "       "       6.

*Euplœine* hind wings 9, fragments 4.

*Papilio demoleus*: fragments 2.

*P. polytes* ♂ or ♀ *cyrus*-form\*: fragments 7  
(2 fore wings).

*P. polytes* ♀ *romulus*: fragments 5 (3 fore wings).

*P. polytes* ♀ *polytes*: hind wing 1.

The predominance of fore wings is explained by their greater weight, hind wings being blown further.

A pair of bee-eaters were feeding near the wood-swallows. Most of their attacks were on small insects; but four attempts on *Catopsilia* and two on *Papilio demoleus* were noted, all of which failed. These bee-eaters were either unskilful or only amused themselves with butterflies. A young Paradise

\* *Papilio polytes* ♀ *cyrus*-form resembles the ♂.

flycatcher and a drongo confined themselves to small insects, in spite of the swarms of butterflies passing.

*December 1st.* Again visited the wood-swallows, but they left off feeding early; the butterfly migration was larger, with a higher percentage of *Euplœa*. It was distinctly observed in one case that the bird carried the butterfly, a *Danaïs septentrionis*, to its perch and then held it with its feet while it pulled the wings off with its beak\*. Watched the bee-eaters again, and saw one attack first a *Papilio agamemnon* Linn. and then a *Euplœa*, but it missed each time. They were continually hawking small insects, which they presumably caught. No count could be made of discarded wings, as all had been blown by a high wind into the river.

*December 2nd.* Again watched the wood-swallows hunting. The butterfly was always carried back to the perch before the wings were removed, and it was noticed that portions of the wings were often left on and eaten. . . . After failing in a stoop, the birds rarely made another at the same insect. . . . Butterflies at some distance were usually taken, perhaps to allow the bird to attain greater pace. . . . If a butterfly noticed that it was being pursued, it at once dodged and, flying rapidly downwards, frequently escaped. Wings were again collected:—

*Danaïs septentrionis*: fore wings 35.

*D. limniace*:                   "       "       4.

*Euplœa core*:                   "       "       18.

*E. coreta*: one whole insect and fore wings 10.

*E. kollari*: fore wings 4.

*Papilio polytes* ♀ *romulus*: fore wing 1.

*December 7th.* Wood-swallows hunting in the afternoon; they usually stop before midday.

*December 10th.* A young Paradise flycatcher swooped at two *Papilio polytes*, a ♂ and a ♀ *polytes* form, which were flying round inside a large breeding-cage, but of course could not get at them.

*December 16th.* A drongo was seen to attack a *Papilio agamemnon* and snap off a portion of the hind wings. The butterfly escaped.

1912. *January 1st-6th* (at Maha Illupalama). Bee-eaters were very common and butterflies, notably of the genera *Catopsilia* and *Appias*, were abundant. The only attack observed was that of a bee-eater on a *Leptosia xiphia* Fabr., which was caught and eaten.

*January 10th* (at Peradeniya). A drongo caught a *Papilio polytes* ♀ *cyrus*-form, which had just emerged and had escaped from a breeding-cage.

*February 22nd.* A *Papilio polytes* ♀ *cyrus* escaped from a cage and was eaten by a drongo; it was flying very weakly, as one wing was broken halfway down the costa.

\* Legge, 'Birds of Ceylon,' vol. ii. p. 668, states that the wood-swallow beats off the wings of its prey.



*March 6th.* Noticed three wood-swallows sitting on the telephone-wires crossing the River Maha-Weliganga. They were hawking butterflies continually, and during the time they were watched selected species of *Euphœa* only from a passing migration which consisted largely of *Appias paulina*. A search for wings failed, as the birds confined themselves entirely to the river. The reason for this seemed to be that the butterflies were only caught with ease when away from cover; among vegetation they dodged their pursuers nine times out of ten. This fact was specially evident during this migration, as species of *Euphœa* and *Danaïs* were uncommon, and the birds were often forced to swoop at butterflies travelling along the river-bank instead of waiting for individuals to come out into the open.

*March 8th.* The migration of butterflies almost ended; but to obtain confirmation, by a fresh witness, of the fact that wood-swallows attack especially members of the genera *Euphœa* and *Danaïs*, Alexander\* and I watched three wood-swallows for an hour, and we both plainly observed them eat over a dozen *Euphœa* and one *Danaïs*. We also saw one bird with a *Papilio*, either *P. polytes* ♀ *polytes* or *P. aristolochiæ*, but were unable to ascertain which. As before, the birds usually carried the butterfly in the beak, though occasionally it was transferred to the claws when the distance back to the perch was great.

*March 15th.* Watched the wood-swallows for three-quarters of an hour; *Appias* spp. common, *Euphœa* and *Danaïs* scarce. There were only two birds feeding, one probably young, for when the other caught a *Danaïs aglæa* Cram. the young one opened its beak and fluttered its wings as if asking for food, though it gained nothing by this proceeding. The old bird then ceased feeding, but the other, possibly encouraged by the sight of the *Danaïs*, worked steadily, soaring round in circles over the river. It caught five *Euphœas* out of seven attempts.

*March 16th.* Watched a wood-swallow for a quarter of an hour and saw it take two *Euphœas*.

*March 17th.* Watched a wood-swallow from 11.30-12. It took two *Euphœas*, but then seemed to have no room for more, as it sat for a long time with the abdomen of the last victim protruding from its mouth like a cigar.

*March 18th.* In five minutes saw two wood-swallows take three *Euphœas* and a *Papilio*, either *P. polytes* ♀ *polytes* or *P. aristolochiæ*, almost certainly the former.

*March 22nd.* Species of *Euphœa* and *Danaïs* abundant on migration. A wood-swallow picked out two *Danaïds* (*D. limniacæ* and *D. septentrionis*) and then a *Euphœa*, after which it stopped feeding.

*March 23rd.* Watched the wood-swallows from 11.40 A.M.-12; two were under observation most of the time, occasionally four. They took six specimens of *Euphœa* and two *D. septentrionis*.

\* Mr. Alexander, Assistant Curator of the Perth Museum, W.A., to whom I am indebted for much critical assistance during his brief visit to the island.

April 23rd. A drongo swooped at and probably took either a *Papilio polytes* ♀ *polytes* or a *P. aristolochiæ*.

April 24th. Mr. Pole of Maskeliya\* wrote that he saw two large dragonflies take two *Appias* sp. ? and one *P. polytes* ♂.

July 7th (at Maha Illupalama). Noticed the remains of *Danaïs septentrionis*, *Papilio jason*, *Appias paulina* and *A. albina*, killed probably by Asilid flies (*Scleropogon piceus* and other species), as the bodies were intact though empty. Asilid flies were twice seen carrying *Appias* sp. ? ♂.

August 8th (at Maha Illupalama). Caught an Asilid fly with a medium-sized dragonfly †, which it was sucking through the eye, and later saw another Asilid killing a large *Cicada* ♂ which was flying madly about, shrieking (stridulating) all the time. A slight bite from an Asilid was most painful, and felt as if poisonous matter had been injected.

August 13th (at Maha Illupalama). Noticed Asilid flies kill *Appias* sp. ? ♂ and *Papilio jason*.

August 28th (at Habarana, Maha Illupalama District). An Asilid attempted to kill the formidable Ceylon hornet, *Vespa cincta*, which, however, escaped.

August 31st (at Trincomalee). A few *Euplœa* wings were found scattered about Fort Osterburg; they were probably dropped by wood-swallows, which were hawking round the inner harbour.

September 1st (Trincomalee). On the Nilavelli-Kuchivelli road bee-eaters were numerous. One was seen to catch an *Appias* sp., and wings of *Euplœa*, *P. jason*, and *Appias* spp. were occasionally found on the ground.

September 7th (at Peradeniya). Released an *Actias selene* ♂. It flew fairly well, but was soon snapped up by a drongo, which, before eating it, first pulled off the "tails" and then the rest of the wings.

The observations having now been given at length, it is perhaps permissible to summarise the impressions gained in their making:—

- i. Butterflies do not form any large percentage of the food of the more common insectivorous birds in Ceylon.
- ii. With the exception of the Wood-Swallow, birds are by no means clever in capturing butterflies.
- iii. The Wood-Swallow is the only bird which actually lives on butterflies, and it almost always chooses butterflies of the so-called nauseous genera *Danaïs* and *Euplœa*; it seemed, however, that this preference was due to the difficulty of catching faster-flying butterflies, and not to the superior flavour of the *Danaïs* or *Euplœa*.

\* Hill district, elevation about 4000 feet.

† This and one or two subsequent notes, though not dealing with butterflies, are included, as they seem worthy of record and yet are insufficient for a separate contribution.

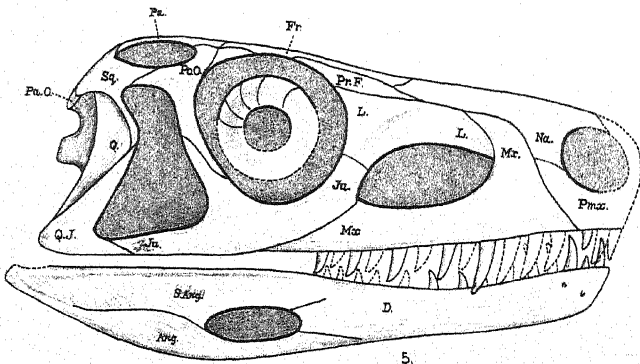
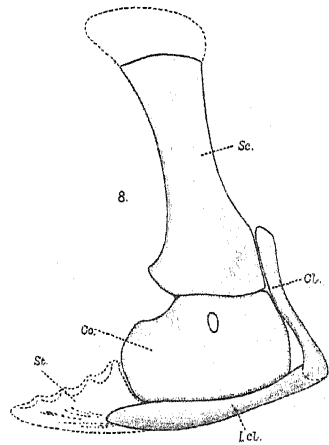
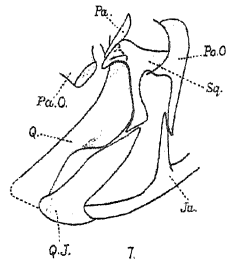
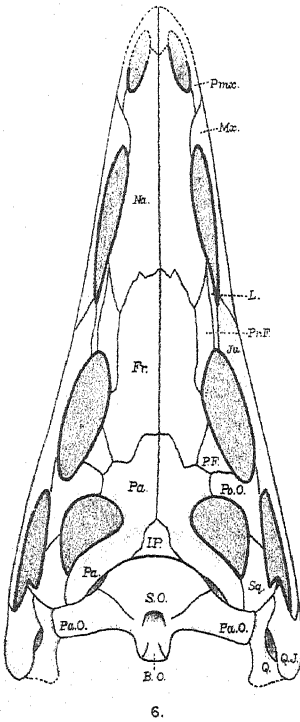




*E. S. C. D. photo.*

EUPARKERIA CAPENSIS.



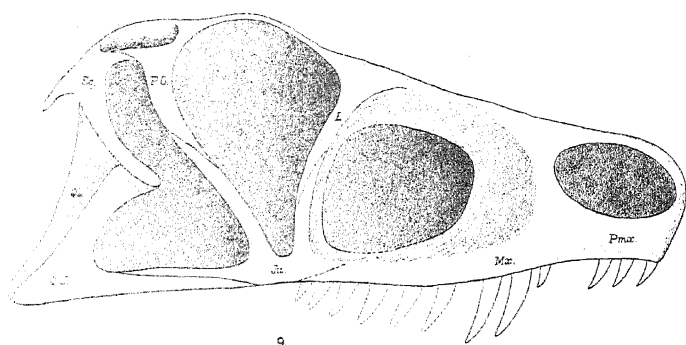


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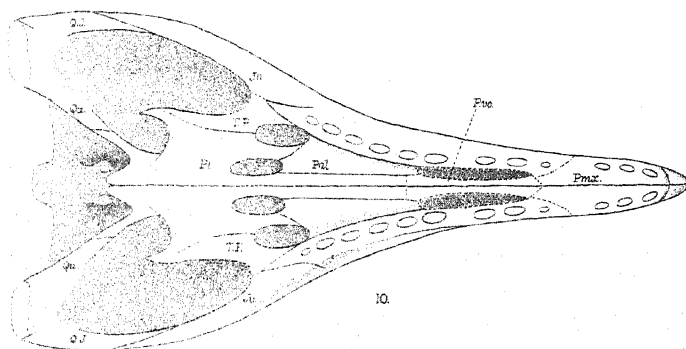
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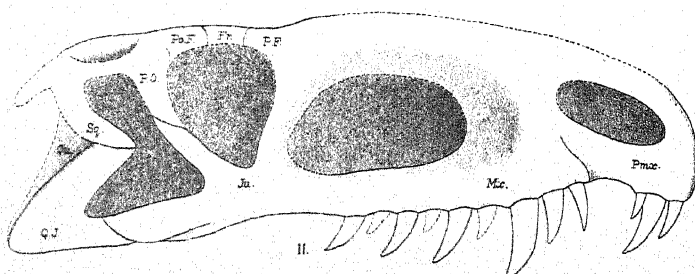




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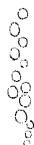
9, 10. ORNITHOSUCHUS WOODWARDI. 11. O. TAYLORI.



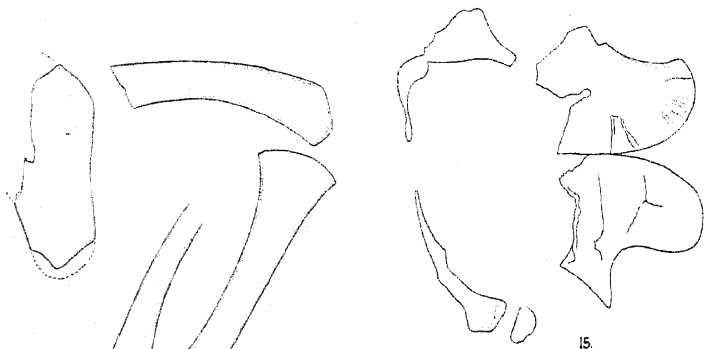




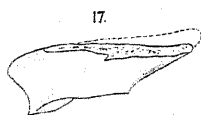
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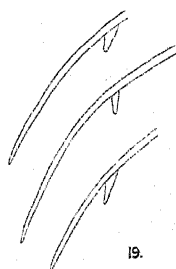
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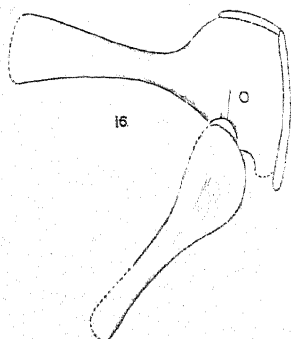
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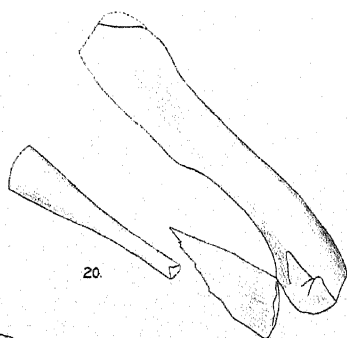
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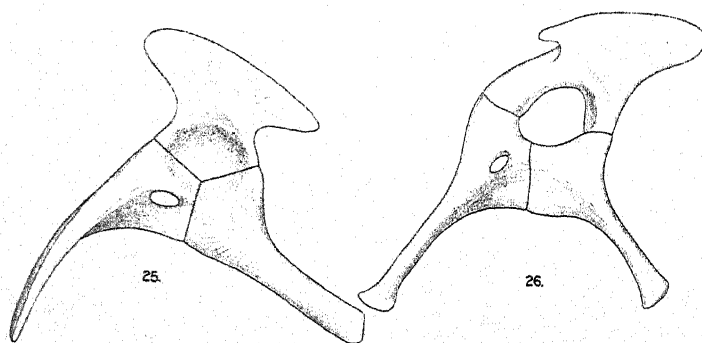
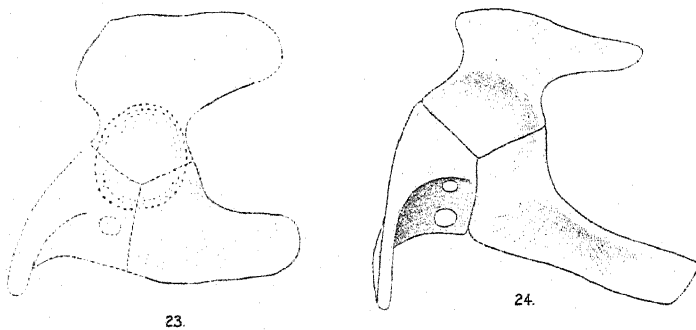
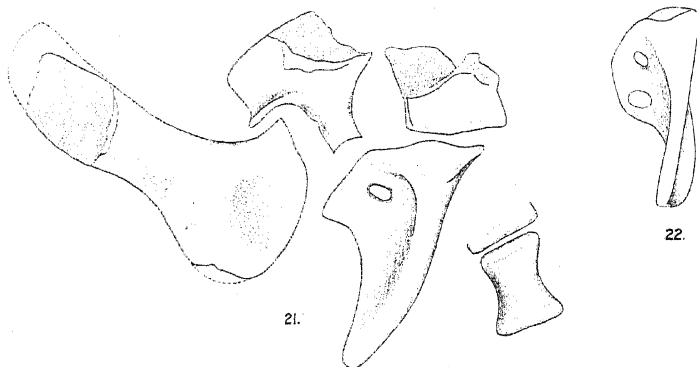
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MESOSUCHUS BROWNI AND OTHERS.





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BROWNIELLA AFRICANA AND OTHERS.

- iv. The various species of Bee-eaters, when attacking butterflies, usually choose members of the Papilionids and Pierids.
- v. The Asilid diptera are formidable enemies to all other living insects. They are, however, present in large numbers only in the northern country, and then only for a limited period of the year.
- vi. In Ceylon a resemblance to the genera *Danaus* and *Euphrosyne* is doubtfully of value; in fact, in the neighbourhood of Wood-Swallows it is a distinct danger.
- vii. The mimetic females of *Papilio polytes* are not obviously protected by their mimicry, and as a whole probably suffer about as much, or as little, from the attacks of birds as any other fast-flying butterfly in Ceylon.

40. On the South-African Pseudosuchian *Euparkeria* and Allied Genera. By R. BROOM, M.D., D.Sc., C.M.Z.S.

[Received and Read May 20, 1913.]

(Plates LXXV.-LXXIX.\*)

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EUPARKERIA CAPENSIS Broom. (Pls. LXXV., LXXVI., LXXVIII., LXXIX. figs. 1-8, 17-20, 22, 24.)

In the collection of Mr. Alfred Brown of Aliwal North are a number of imperfect skeletons of a small Rhynchocephaloid reptile of very great interest, which he discovered in Upper Triassic beds about four years ago. Mr. D. M. S. Watson examined them a year ago, but unfortunately he mistakenly regarded them as belonging to the little acrodont-toothed reptile named by him *Mesosuchus browni*. Though the two forms were met with together and are of about the same size, they certainly belong to different families, if not to different suborders. In a short note communicated to the 'Records of the Albany Museum' (6), I have called attention to the confusion and proposed the name *Euparkeria capensis* for the Thecodont form.

As the type, I take a specimen showing a beautiful skull with most of the skeleton. Though this specimen was in the

\* For explanation of the Plates see p. 633.

collection as seen by Watson, it was scarcely at all developed, and he did not recognise that the block of stone contained an almost perfect skull which, had he seen it, would have prevented the confusion of the two animals.

In the type specimen is preserved the skull almost complete but slightly crushed, and with the bones in beautiful condition and showing nearly every detail of structure. A number of cervical and dorsal vertebrae are shown, both coracoids, the interclavicle; the right clavicle and scapula, and the right humerus, radius, and ulna. There are also seen in the specimen the whole of the abdominal ribs in perfect condition, the pelvic bones in good condition, but displaced, and most of the left hind limb. Other specimens show the pelvic bones in position and most of the tail. One specimen shows a dentary with a perfect right pes.

The skull is very similar to that of *Ornithosuchus woodwardi*, and there can be little doubt but that *Euparkeria* belongs to the same suborder and to the same family, though the two genera must be regarded as distinct. From the snout to the occipital condyle the skull measures about 83 mm. From the snout to the front of the orbit is about 45 mm. The orbit is almost round and has an antero-posterior diameter of 23 mm. There is a large antorbital vacuity about 20 mm. in length. The infra-temporal opening measures 18 mm. in height and its greatest antero-posterior length at its lower part is 17 mm. The supra-temporal fenestra is small, measuring 13 mm. by 10 mm. The width across the frontals between the orbits is 14 mm., and the width across the squamosals where they form the temporal arch is 34 mm.

The front part of the premaxilla is missing from the type, but it was probably somewhat similar to that in *Ornithosuchus* and other allied types. It forms the lower half of the posterior margin of the rather large nostril. It supports at least two and most probably three flattened pointed thecodont teeth.

There is no evidence of a septo-maxillary on the face.

The maxilla is a long slender bone, which forms the lower and anterior borders of the antorbital vacuity. The anterior ascending process passes up behind the premaxilla and the descending anterior portion of the nasal, and meets the anterior end of the large lacrymal. The posterior horizontal portion passes back to below the middle of the orbit and meets the jugal. It supports apparently 13 thecodont teeth, of which 5 are preserved in the specimen. These are pointed flattened teeth, very similar in general shape to those of carnivorous Dinosaurs. They are feebly serrated behind and probably also in front.

The nasal is rather peculiar in shape. When viewed from above, it appears as a long narrow bone about twice as wide behind, where it meets the frontal, as in front. In reality the front is as wide as the back part, as it forms a curious downward process behind the nostril to meet the premaxilla. The peculiar shape will best be understood from the figures.

The lacrymal is an unusually large bone. It forms most of the anterior orbital margin. Above, it has a long articulation with the prefrontal, and below, a short one with the jugal. Anteriorly, it has a large development which forms the upper margin of the antorbital vacuity meeting the ascending process of the maxilla. Of the anterior process much is below the level of the general surface of the face, suggestive of the antorbital vacuity having lodged a large gland.

The prefrontal is a small narrow bone which forms about half of the upper orbital margin. It is bounded above by the frontal and nasal and below by the lacrymal.

The frontal is a long narrow bone. Behind, it articulates with the parietal and laterally with the postfrontal, and in front with the nasal and laterally with the prefrontal. It only forms a small part of the orbital margin.

The postfrontal is a small triangular bone which articulates with the frontal, parietal, and postorbital, and forms a small part of the upper orbital margin.

The postorbital is a triradiating bone. The upper process passes upwards behind the postfrontal and meets the parietal. The inferior process passes downwards and articulates with the jugal, partly lying in front of it and forming with it the postorbital arch. The posterior process is short. It meets the squamosal and forms with it the temporal arch.

The jugal is also a triradiating bone. The anterior process is the strongest. It forms most of the infraorbital arch, forming a long suture with the maxilla and meeting the lacrymal. The upper process meets the postorbital and forms with it the postorbital arch. The posterior process is long and slender and forms the zygomatic arch meeting the quadrato-jugal.

The quadrato-jugal is an angular bone which supports the quadrate and the jugal and binds them together. Above, it meets the squamosal. A large foramen is present between the quadrato-jugal and the quadrate near the lower part of the bone.

The squamosal is small but fairly strong. It may be regarded as a clasping bone which holds together the quadrate, quadrato-jugal, postorbital, parietal, and opisthotic. A small upper process lies in front of the lateral process of the parietal. The relations to the quadrato-jugal and quadrate will be better understood by the figures given.

The quadrate is a long, well-developed bone. Its upper end is firmly articulated with the squamosal and possibly also with the opisthotic, and also meets the quadrato-jugal. The lower end forms the articulation. There is a large opening between the quadrate and quadrato-jugal. The shape of the bone is seen in the drawings given.

The parietal is smaller than the frontal. It forms the back part of the upper cranial wall and has a postero-lateral process which forms much of the posterior wall of the upper temporal

fossa, and at its outer end meets the squamosal. There is no trace of a pineal foramen.

Behind the parietals and partly wedged between them is a small interparietal. It forms the upper part of the occiput, and partly divides the parietal from the supraoccipital.

The supraoccipital forms the middle part of the occiput. It articulates with the exoccipitals, the interparietal, and the parietals.

The exoccipital forms part of the occipital condyle and passes outwards, fusing with the opisthotic.

Only a small part of the basioccipital shows in the specimen as the middle part of the condyle.

The lower jaw is well preserved. The dentary forms the anterior half, and the angular and surangular the greater part of the posterior half. A large oval opening is seen on the outer side of the jaw between the angular and surangular.

A pair of long rib-like bones represent portions of the hyoid apparatus. These are evidently the ceratobranchials, and indicate that *Euparkeria* had a birdlike tongue.

There are well-developed sclerotic plates in the eye, which are curved as in the bird.

Two slightly displaced bones are probably the proatlas and portion of the atlas. There are probably about 9 or 10 cervical vertebrae, of which the upper 3 or 4 are hidden by matrix. The lower cervicals have comparatively short centra. They are practically amphiplatyan or incipiently procelous. The ribs are double-headed and have small uncinate. There are 2 sacral vertebrae, and apparently 26 presacral. The tail is very long and has powerful chevrons.

The shoulder-girdle is well preserved. There is a long slender interclavicle which is apparently narrow even at its anterior end. The clavicle is also long and slender. The coracoid\* is large, measuring 24 mm. in antero-posterior diameter and 16 mm. in its transverse diameter. There is a large oval foramen near the scapular articulation and a little in front of the median plane of the bone. The scapula is long and slender. It measures in greatest length 38 mm., and its lower end is 15 mm. across and the upper end 12 mm. in width. There is no distinct acromion process, and the clavicle has been probably rather loosely attached to the front of the lower third of the bone.

The humerus is very slender. Its length is 36 mm. Only the outer aspect is displayed, and it cannot be seen whether there is an entepicondylar foramen. There is no indication of an ectepicondylar foramen. The deltopectoral ridge is very short.

The radius and ulna are slender straight bones. The radius measures 32 mm. in length and the ulna is probably slightly longer. The manus is lost from the specimen.

\* Though to avoid any confusion I have used the universally accepted term "coracoid," as I have elsewhere recently shown the bone ought more properly to be called the "precoracoid."



There is a large broad plastron of abdominal ribs which occupies the whole of the front of the abdomen, from a little behind the coracoid to the front of the pubis. The riblets are all slender and arranged in series of threes—a long outer riblet, a shorter middle one, and a still shorter inner one. In front the innermost series remain free, but on passing back they become anchylosed into united groups of two, three, and four. There are probably four series of riblets to each vertebra. Altogether there are 31 groups of ribs.

The pelvis is preserved in two specimens besides the type, and every detail of its structure is known. The ilium is similar to the type found in *Belodon* and *Erythrosuchus*. The acetabulum is large, and closed, and the ilium has a well-marked supra-acetabular ridge. The iliac crest is developed much more backwards than forwards, and the whole crest measures 28 mm. in length. The pubis is comparatively short and broad. It forms a complete symphysis with its neighbour, and the outer border, which is considerably thickened, passes almost directly downwards. A very remarkable feature of the bone is the presence of two pubic foramina. The upper one, which is apparently the homologue of the normal pubic foramen, is the smaller of the two and is fairly close to the acetabulum. The other is close to the symphysis. In the type specimen both pubes are well preserved and the foramina are exactly similar on both sides. The ischium is a variety of the plate-like form, but long and slender. It has a complete symphysis with the other ischium.

The femur measures in the type 58 mm. : in a second specimen 55 mm. It has a slight double curve as in most reptilian femora. The ends have been largely cartilaginous. On the inner and posterior side, near the union of the upper and middle third, there is a well-marked small trochanter.

The tibia and fibula are not perfectly preserved in any of the specimens, but in one or other both upper and lower parts are shown. They are apparently a little shorter than the femur and considerably more slender.

The tarsus consists of two proximal elements, and probably four distal tarsals. The astragalus is irregularly cubical, and the calcaneum considerably broader than long. There appears to be little in the way of a heel. Of the distal tarsals the 4th is the only large one.

The metatarsals are all well developed, and the 5th has the peculiar Rhynchocephalian development. Of the others the 3rd is the longest. The 4th is slightly longer than the 2nd, and the 2nd considerably longer than the 1st. The 1st, 2nd, and 3rd digits have well-developed claws, but the 4th has the phalanges rather weak and the claw, if present, was very small. The 5th toe also has a small claw, though larger than that of the 4th. The digital formula is 2, 3, 4, 5, 3.

Dermal ossifications are present along the back from the head to at least well down the tail. These are arranged in pairs, one

on each side of each vertebral spine. All the best preserved scutes are about twice as long as broad and have the long axis lying antero-posteriorly.

Some at least of the ribs of the middle region of the body appear to have uncinate processes. These are little ossifications about 3 or 4 mm. in length and about 1 mm. in width. They are firmly attached to the posterior side of the ribs but not ankylosed. Just possibly, though much less probably, they are small lateral dermal scutes.

Before discussing the affinities of *Euparkeria* and the Pseudosuchians generally, it will be well to consider some points in the structure of the allied genera from Elgin. These very interesting specimens, preserved in the British Museum, reveal a few points in the structure of the group not seen in the specimens of *Euparkeria*, and afford a very thorough knowledge of the suborder. *Aëtosaurus ferratus*, on which the suborder Pseudosuchia was founded, has never been very thoroughly described, but Mr. Watson assures me that there is no doubt that it has two temporal vacuities like those of *Euparkeria* and *Ornithosuchus*, and not one as described and figured by Fraas. Though there is thus little doubt that *Aëtosaurus* belongs to the same suborder, it differs in a good many points from the Elgin and South-African forms.

ORNITHOSUCHUS WOODWARDI Newton. (Pls. LXXVII.-LXXIX., figs. 9, 10, 16, 25.)

The type of this Pseudosuchian is a fairly complete skeleton from Elgin, described in 1894 by Mr. E. T. Newton. The specimen is preserved in the British Museum, and through the kindness of Dr. Smith Woodward I have been enabled to make a fresh study of it in the light of the new knowledge obtained from the allied South-African form. Newton's study of the type has been so thoroughly and carefully done that there is very little in the specimen he has failed to observe, and the points where I incline to differ from him are very few in number. Fortunately the British Museum has recently obtained a second specimen which supplies a number of blanks in our knowledge.

The skull, on the whole, resembles that of *Euparkeria* in all essentials, so far as can be seen, though the cranial sutures are less easily made out in *Ornithosuchus* and the palate is unknown in *Euparkeria*. The skull of *Ornithosuchus woodwardi* is more slenderly built, and it differs in having apparently no interparietal, in the shape of the jugal, in having a much larger antorbital vacuity, and in having the teeth differently arranged. In the restored side view of the skull which I give, and which differs only slightly from that given by Newton, the shape of the various openings and bones can readily be seen. The dental formula of *Ornithosuchus* appears to be i.3, m.9 as against i.3, m.12 in *Euparkeria*; and there is the further difference that, while in the South African genus only one mandibular tooth overlaps the upper jaw-border, in *Ornithosuchus* there are two

teeth which pass to the outside between the premaxillary and maxillary teeth.

The palate of *Ornithosuchus* is well preserved but not completely displayed in front. The restoration of it which I give is hypothetical only in the prevomerine region and in the basioccipital. The pterygoids are large, as are also the palatines and ectopterygoids, and these three bones of the two sides form a large vaulted bony roof to the mouth. On each side there is a pair of oval openings—one between the palatine, the ectopterygoid, and the pterygoid, and the other between the pterygoid and the palatine. This latter is regarded by Newton as the posterior nares. In this, I think, he is in error. The opening has the borders quite flat, and was probably covered by membrane in life and did not transmit any structure of importance. The pterygoid sends forward a long slender process along the inner side of the palatine which doubtless meets the prevomer as suggested in the figure.

The shoulder-girdle and anterior limb, though lost from the type, are fairly well preserved in the second specimen. The scapula differs from that of *Euparkeria* in being very narrow in the middle and much more expanded at the base. It is much more Dinosaurian in appearance. The coracoid has a rather small foramen, and the posterior border below the glenoid cavity is deeply notched. The interclavicle is narrow and not expanded in front apparently. The clavicles are also slender.

The humerus measures 57.5 mm. in length. There is a well-developed deltopectoral crest, and the general appearance of the bone suggests a comparison with that of the Theropoda. The radius and ulna are not very well preserved. The former measures 47 mm. and the latter 49 mm. Only a few bones of the manus are preserved, and these are apparently displaced. A cast of a specimen obtained by Mr. Watson shows rather more of the manus. There are pretty certainly three well-developed digits, and, I think, evidence of a fourth. The carpus is badly preserved: possibly it was imperfectly ossified.

I have given a restoration of the pelvis for most of which, I think, there is clear evidence in the specimen. The pubis is essentially similar to that of *Euparkeria*, but much more elongated. It has a large single pubic foramen. There is evidently a complete symphysis.

The bones of the hind foot of the type, though much displaced, have been separated out and identified by Newton with marvellous care, and the foot is seen to resemble that of *Euparkeria* pretty closely, the main difference being that the fifth metatarsal shows less of the peculiar Rhynchocephalian development, and the phalanges of this, too, are feebler.

*ORNITHOSUCHUS TAYLORI*, sp. n. (Pl. LXXVII. fig. 11.)

In 1904, Mr. G. A. Boulenger described some rather badly preserved reptilian remains from Elgin as a large example of *Ornithosuchus woodwardi*. Mr. Taylor, when sending the

specimen to the British Museum, recognised that it was a near ally of *Ornithosuchus woodwardi*, though about  $2\frac{1}{2}$  times as large. Mr. Boulenger discusses at some length the question whether the specimen is merely an older example of *O. woodwardi* or a new species, and comes to the conclusion that there are no other differences than those that might be accounted for by difference of age. My comparison of the specimens has led me to conclude that the animals, though allied, are at least distinct species, and I have therefore much pleasure in naming the form after the discoverer.

The specimen shows most of the skull. The jugal is probably perfect but is partly hidden by matrix, and the quadrato-jugal is also nearly perfect. The squamosal and postorbital are much crushed, but the side view of the back half of the skull can be restored with moderate accuracy. Most of the upper side of the skull is preserved, but partly broken and not well displayed. A fairly complete snout with maxilla and premaxilla of what may perhaps be a second individual is also preserved. And as we have the remains of the last maxillary tooth in the first specimen, and the corresponding tooth in the snout-fragment, we can make a fairly complete restoration of the skull. When this is done, the very marked differences between it and the skull of *Ornithosuchus woodwardi* are apparent. The arches are seen to be massive instead of slender bars, and the snout relatively much more powerful. The fact of the two animals being distinct is further confirmed by the fact that the British Museum has recently obtained from Elgin two new specimens—the one exactly corresponding in size to the type of *Ornithosuchus woodwardi*, and the other, so far as can be made out, agreeing in size with the large form. In the new specimen of *O. taylori* part of the palate is preserved, and it agrees essentially with that of *O. woodwardi*. There are two similar openings in the back part, and the pterygoid sends forward a similar but relatively larger anterior process.

#### HERPETOSUCHUS GRANTI Newton.

This small Pseudosuchian from Elgin is less satisfactorily preserved than *Ornithosuchus woodwardi*, but there is sufficient to show that it is a fairly near ally. The skull differs considerably in its proportions, but probably the essential structure is similar. The palate is narrower, and the anterior process of the pterygoid is relatively broader, and there is only a single opening in the pterygoid region. The shoulder-girdle and anterior limb are differently proportioned, being much more slender, and indicate that the habits of the two genera were different. An interesting point revealed by this specimen is the fact that the manus has five well-developed digits. In the carpus there are at least three elements. The five metacarpals are well preserved, but most of the phalanges are missing.

## BROWNIELLA AFRICANA, gen. et sp. n. (Pl. LXXIX. fig. 21.)

In Mr. Brown's collection there are portions of at least two skeletons of an animal rather larger than *Euparkeria capensis* but closely allied to it. The only parts well preserved are the shoulder-girdle, pelvic girdle, and femur. These indicate an animal nearly a half larger than the better known African form.

The following measurements will illustrate the differences in size of the two forms:—

	<i>Euparkeria</i> <i>capensis</i> . mm.	<i>Browniella</i> <i>africana</i> . mm.
Width of base of scapula .....	15	20
Length of coracoid .....	24	30
Length of ischium .....	36	about 50
Length of femur .....	56	74

In general structure there is a close similarity between the bones, but those of *Browniella* are more massive, and there are numerous minor differences.

The ischium differs in shape in being constricted near its middle, and the pubis, besides being much broader and stouter, differs in having only a single pubic foramen. This difference seems of sufficient importance to justify the placing of this species in a separate genus, and I have much pleasure in naming it after Mr. Alfred Brown, the veteran collector, to whom Science owes such a deep debt.

## MESOSUCHUS BROWNI Watson. (Pls. LXXVIII., LXXIX. figs. 12-15, 23.)

Though *Mesosuchus browni* differs considerably from *Euparkeria* and is probably not a Pseudosuchian, it has nevertheless some interesting affinities, and, both from its association with *Euparkeria* and from the fact of the two forms having been confused, it seems well to consider the one along with the other.

As already mentioned, Watson, in his description of *Mesosuchus browni*, had regarded some of the imperfect skeletons associated with it as belonging to the same form. As we now know that most of these skeletons belong to the similar sized but distinctly different *Euparkeria capensis*, it is necessary to redefine *Mesosuchus* to some extent.

The type specimen consists of a badly crushed skull showing the premaxilla and maxilla of the left side in good condition, with most of the lower jaw and most of the palate badly crushed. Much of the rest of the skull is present, but so badly distorted that a restoration is difficult. Of the rest of the skeleton of the type individual almost the whole of the vertebral column from the head to about the middle of the tail is preserved. Of the shoulder-girdle there is practically nothing preserved, though much of the

right arm is seen. The pelvis is badly preserved, but both ischia are well seen and most of the left hind leg.

The premaxilla is particularly interesting in having no inter-nasal process, and in this resembling the bone in *Rhynchosaurus* and *Hyperodapedon*. It has two well-developed acrodont teeth, which are round and blunt. The maxilla is long and narrow, and has 13 irregularly arranged rounded blunt acrodont teeth. A disarticulated quadrate, which is not that of *Euparkeria* and pretty certainly that of *Mesosuchus*, is nearly as broad as long, and much more massive than the quadrate of *Euparkeria*. There are two moderately distinct condyles. Watson's description of the palate cannot at present be added to. "Pterygoid of remarkable shape with a deep posterior ramus applied to the inner side of the quadrate, small external ramus (not well exposed) and long anterior ramus which bears a closely-set series of small pointed teeth. Vomer apparently narrow, with a series of small pointed teeth articulated with anterior end of pterygoid. Other bones of palate not shown. Epipterygoid widened with a deep notch for the optic nerve, touching the top of the deep posterior ramus of the pterygoid. Parasphenoid very large and placed high up in the skull." Most of the postcranial skeleton described by Watson are really bones of *Euparkeria*, while the supposed scapula is really the ischium of *Browniella africana*.

The lower jaw is fairly well preserved in the type specimen. It differs from the jaw of *Euparkeria* in having a relatively small lateral opening and in having the part of the jaw behind the opening larger than the dentary portion. The surangular forms more than the upper half of the outside of the back of the jaw, and the rest is mainly formed by the angular.

The vertebrae are not well preserved. They are of about the same size as those of *Euparkeria capensis*. The cervicals have fairly long spines, and the whole neck is relatively longer than in *Euparkeria*—probably 11 vertebrae may be cervical. Altogether there appear to be, as in *Euparkeria*, 26 pre-sacral vertebrae, and apparently 2 sacral.

The humerus, radius, and ulna are much more massive than in *Euparkeria*, but not very well preserved. The humerus measures 37 mm. in length.

The ilium differs considerably from that of *Euparkeria*, and resembles much more closely that of *Hovesia*. Though imperfectly preserved, the upper part of the ilium is manifestly about twice as deep as in *Euparkeria*. The ischium also differs markedly from that of *Euparkeria* in being relatively much shorter, and having only a short symphysis. The pubes are very badly preserved, but have manifestly been much broader than in *Euparkeria*, though essentially similar in type. The illustrations given show the specimen as preserved and the pelvis restored.

The femur, tibia, and fibula are not unlike those of *Euparkeria*. The femur probably measures 49 mm. in length, and the tibia 47 mm. The tarsus has the bones displaced, but is apparently

better ossified than in *Euparkeria*. There are three large elements and at least two small ones. The rest of the pes is probably of the Rhynchocephalian type.

There seem to have been no dermal ossifications in *Mesosuchus*.

#### SCLEROMOCHLUS TAYLORI Smith Woodward.

One of the most remarkable of the double-arched reptiles from the Elgin sandstone is the little form named by Dr. Smith Woodward *Scleromochlus taylori*. Though there are preserved in the British Museum the remains of five individuals, and though something is known of most of the skeleton, the animal is too small to be well preserved in the coarse sandstone, and hence our knowledge of the detailed structure is very imperfect. Smith Woodward's description and restoration give practically everything one can be sure about. The skull seems to be essentially similar to that of *Ornithosuchus*.

#### Affinities of the *Pseudosuchia*.

Mr. E. T. Newton, in describing *Ornithosuchus* and *Herpetosuchus*, discusses the affinities of the forms. He calls attention to the marked resemblances of the forms to *Aëtosaurus*, and even thinks it possible—as we now know to be the fact—that *Aëtosaurus* has an infratemporal vacuity, and also discusses the relationships with *Stagonolepis* and others of the Parasuchia. A comparison is also made with the Dinosaurs *Compsognathus*, *Anchisaurus*, and others, and with the skull resemblances in the Pterosaurian *Scyphognathus*. In summing up the evidences he says:—"The many points of resemblance between the Parasuchia and certain of the forms usually included among the Dinosauria, have also been noticed by other writers; and the difficulty of separating the two groups is increased by a study of this new Elgin reptile, which holds, as I think, a more intermediate position between the two series than any form hitherto described, for although the characters of its skull and teeth find their nearest counterpart among the Dinosaurs, and the pelvis and limbs might belong to either a Theropodous Dinosaur, or a Parasuchian, the form of the free astragalus is more Crocodilian than Dinosaurian. While acknowledging the difficulty of assigning this new reptile to either of these groups, it seems most in accordance with the facts to place it provisionally with the Dinosaurs."

Mr. G. A. Boulenger, when describing the large specimen of *Ornithosuchus*, criticises Newton's conclusions. He says:—"Much as I admire Mr. Newton's description of *Ornithosuchus* . . . I cannot . . . endorse his conclusions as to the systematic position of the reptile." "Dr. Smith Woodward was nearer the truth when he compared it with *Aëtosaurus*." Boulenger argues that *Ornithosuchus* should be placed with *Belodon*, *Stagonolepis*, and *Aëtosaurus* in the order named by Owen, Thecodontia—a

group which agrees quite as much with the Rhynchocephalia and the Carnivorous Dinosaurs as with the Crocodilians.

Though these two opinions seem at first sight to be at variance they are really pretty similar. Practically, it amounts to this, that in the Pseudosuchia we have a group of primitive reptiles which, while they do not fit into any of the later specialised orders, have affinities with quite a number of other groups.

There cannot, I think, be the slightest doubt that the Pseudosuchia have close affinities with the Dinosaurs, or at least with the Theropoda. This has been recognised by Marsh, v. Huene, and others. In fact there seems to me little doubt that the ancestral Dinosaur was a Pseudosuchian. The skulls of such types as *Euparkeria* or *Ornithosuchus* are practically Dinosaurian even in detail, and the skulls of the early Dinosaurs, such as *Anchisaurus*, differ less from the skulls of Pseudosuchians than those of the early Dinosaurs do from many of the later types. And there is nothing in the post-cranial skeleton that is not just what we should expect to find in the Dinosaur ancestor. The shoulder-girdle is more primitive in retaining clavicles and interclavicle, but these are elements which we know from the history of other groups are very variable and readily lost. The pelvis is almost Dinosaurian, and differs only in having the acetabulum closed. This is an important character; but when we consider the condition in the two nearly allied Monotremes—the one with the acetabulum closed, the other with it open—we see how easily even this character may change. The hind limb is almost Dinosaurian in *Euparkeria*. The ankle is less specialised and the fifth toe is still well developed and retains the Rhynchocephalian characters. *Euparkeria* is in my opinion potentially bipedal, and was probably partly bipedal in its habits. The fourth toe of the hind foot is more feebly developed than the third and the axis of the foot is down the third toe, which would seem to indicate that the feet were at least not so laterally placed as in lizards, and that the animal possibly ran on its hind feet. The relative shortness of the toes also seems to confirm this view, as well as the feebleness of the fore limbs. I believe *Euparkeria* fed on some large forms of insects like locusts, and captured them with its front feet.

*Ornithosuchus* was probably very similar in habit to *Euparkeria* and was even a little better adapted for running on its hind feet; the large species *O. taylori* could hardly have had the same habits as the small *O. woodwardi*. It is too massively built, and probably had become largely carnivorous, adding to the larger insects various small vertebrates, and perhaps, like the vulture, the flesh of animals too large for it to kill.

The affinities of such small Pseudosuchians as *Euparkeria*, *Ornithosuchus*, and *Aëtosaurus* with the Belodonts through such an intermediate form as *Erythrosuchus* is very manifest. And as Boulenger stated, the Pseudosuchians are about as near to the Parasuchians as to the Dinosaurs. The series of dermal plates down the back, though suggesting affinity is, however, not a



character on which too much weight must be placed. As we see in the Lacertilia, dermal ossifications are subject to great variation in even allied forms.

Another group to which the Pseudosuchians seem to have affinities as suggested by Newton, is the Ornithosauria. In general proportions the Pterodactyles differ very greatly, but the form from which they arose must have been very much like that seen in Pseudosuchians. The Pterodactyl and Pseudosuchian skulls are almost exactly similar in essentials. As pointed out by Newton, the skull in *Scyphognathus* resembles pretty closely that of *Ornithosuchus*. The Pterodactyl manus is simply an ordinary reptilian manus with the 5th digit lost and the 4th greatly specialised, and there can be no doubt that the 5th digit was lost before the wing-membrane was developed. The pelvis of the Pterodactyl is not thoroughly known beyond doubt, but seems to be a modification of the ordinary plate-like type with the prepubis ossified.

*Scleromochlus* is a very lightly built Pseudosuchian evidently adapted for taking leaps, and not for bipedal progression on the ground. The limbs are long and slender, and the length and slenderness of the fore limb suggest that possibly there was a membrane stretched between the fore and hind limbs and perhaps between the hind limbs and tail, which would enable the little animal to take sustained leaps like *Petaurus*.

Although *Scleromochlus* is already too specialised in the hind foot structure to have been in any way ancestral to the Pterodactyls, it may suggest how they have arisen, just as *Galeopithecus* suggests how the bats arose.

There is still another group to which some Pseudosuchian has probably been ancestral, namely, the Birds. For a time one or other of the Dinosaurs was regarded as near the avian ancestor. The resemblance of the hind limb and pelvis seemed to make this extremely probable, and Huxley, Marsh, Cope, and others have all favoured this view. Others, however, were more impressed by the apparently avian characters in the skeleton of the Pterodactyls, and especially in the striking avian appearances in the brain, and have argued in favour of a close affinity between the Birds and the Pterodactyls. Osborn, while recognising the affinities to both groups, and especially to the Dinosaurs, believed that the Birds and the Dinosaurs had a common ancestor, probably in the Permian. Seven years ago, when describing the skeletogenesis of the Ostrich, I argued that the bird had come from a group immediately ancestral to the Theropodous Dinosaurs. The Pseudosuchia, now that it is better known, proves to be just such a group as is required. In those points where we find the Dinosaur too specialised we see the Pseudosuchian still primitive enough. The bird pelvis has probably developed from a type like that of *Ornithosuchus* by the pubis turning further back and the symphysis becoming lost. Whether the union of the metatarsals is a primary or a secondary character is a debatable point. The question is really whether the bird ancestor was a hopping

bipedal animal before it flew, or if it only hopped after the wing had become specialised. I am strongly of the opinion that it was a hopping animal first, and that the metatarsus became strengthened to support the weight of the body entirely borne by the hind feet. It is easy to understand a hopping animal taking to an arboreal life and ultimately developing a wing out of a four-toed hand, while it seems unlikely that the hind foot could ever have developed by arboreal habits. It is interesting to note that while the ancestor of the Pterodactyls had four toes in the manus, there is very clear evidence from the skeletogenesis of the bird that the latter also had a four-toed ancestor.

A Pseudosuchian which through a bipedal habit had developed a strengthened ankle-joint and a firm metatarsus, and had lost the 5th digit from the manus would meet all the requirements of the avian ancestor.

We know at present too little to discuss the relationship of the Pseudosuchians with *Sphenodon* and with Gnathodonts, nor can we say whether *Howesia* and *Mesosuchus* should be placed with the Pseudosuchians. There is evidence of a generalised Permian Rhynchocephaloid order which gave rise to the more specialised Triassic groups, but at present we know too few forms and very few even of these are well known, and until our knowledge has much advanced it seems unwise to attempt any further classification. In South Africa we can trace through the Lower Triassic and Upper and Middle Permian beds forms that may be ancestral to the Pseudosuchians, and when these are better known a satisfactory classification will be possible.

I am much indebted to Mr. E. S. C. Dyke for the photographs of *Euparkeria*.

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- (2) G. A. BOULENGER.—“On Reptilian Remains from the Trias of Elgin.” Phil. Trans. vol. 196 B, 1903, p. 175.
- (3) A. S. WOODWARD.—“On a new Dinosaurian Reptile (*Scleromochlus taylori*) from the Trias of Lossiemouth, Elgin.” Q. J. G. S. vol. lxiii. 1907, p. 140.
- (4) F. v. HUENE.—“Die Dinosaurier der Europäischen Triasformation.” Geol. u. Pal. Abhand., Jena, 1907.
- (5) D. M. S. WATSON.—“*Mesosuchus browni*, gen. et spec. nov.” Rec. Albany Mus. vol. ii. pt. iv. p. 296.
- (6) R. BROOM.—“Note on *Mesosuchus browni* Watson, and on a new South-African Triassic Pseudosuchian (*Euparkeria capensis*).” Rec. Albany Mus. vol. ii. pt. v. 1913, p. 394.

A full list of other papers will be found in v. Huene's work.

## EXPLANATION OF THE PLATES.

*Ang.* Angular. *Bo.* Basioccipital. *Cl.* Clavicle. *Co.* Coracoid. *D.* Dentale, *Fr.* Frontal. *I.cl.* Interclavicle. *I.P.* Interparietal. *Ju.* Jugal. *L.* Lacrymal, *Mr.* Maxilla. *Na.* Nasal. *Pa.* Parietal. *Pao.* Paroccipital. *Pmr.* Premaxilla. *Po.F.* Postfrontal. *Po.O.* Postorbital. *Pr.F.* Prefrontal. *Q.* Quadrate. *Q.J.* Quadrato-jugal. *S.Ang.* Surangular. *Sc.* Scapula. *S.O.* Supraoccipital. *Sq.* Squamosal. *St.* Sternum.

## PLATE LXXV.

*Euparkeria capensis.*

- Fig. 1. Side view of type specimen.  $\frac{2}{3}$  nat. size.  
 2. Top of skull of type specimen. Nat. size.  
 3. Left dentary of a second specimen. Nat. size.  
 4. Right hind foot of this second specimen. Nat. size.

## PLATE LXXVI.

*Euparkeria capensis.*

- Fig. 5. Side view of skull. Nat. size.  
 6. Upper view of skull.  
 7. The quadrate viewed obliquely from behind, showing the relations to the adjoining bones. Small portions of the squamosal and opisthotic are broken off.  
 8. Shoulder-girdle, slightly restored and with the probable cartilaginous sternum added in dots. Nat. size.

## PLATE LXXVII.

- Fig. 9. Side view of skull of *Ornithosuchus woodwardi*. Nearly nat. size.  
 10. Under view of skull of *Ornithosuchus woodwardi*. Nearly nat. size.  
 11. Side view of skull of *Ornithosuchus taylora*. About  $\frac{2}{3}$  nat. size. Restored from the type specimens.

## PLATE LXXVIII.

- Fig. 12. Side view of imperfect skull of *Mesosuchus browni*. Nat. size.  
 13. Impression of the teeth of the right maxilla of *Mesosuchus browni*. Nat. size.  
 14. Fragment of ilium, and left hind limb of *Mesosuchus browni*. Nat. size.  
 15. Fragmentary pelvis of *Mesosuchus browni*. Nat. size.  
 16. Shoulder-girdle and fore limb of *Ornithosuchus woodwardi*. About  $\frac{1}{2}$  nat. size. Slightly restored.  
 17. Top of left ilium of *Euparkeria capensis*. Nat. size.  
 18. Acetabular portion of left ilium of *Euparkeria capensis*. Nat. size.  
 19. Portions of three lower dorsal ribs of *Euparkeria capensis* showing uncinate. Nat. size.  
 20. Right femur, tibia, and fibula of *Euparkeria capensis*. Nat. size.

## PLATE LXXIX.

- Fig. 21. Right pubis, left ischium, portions of both ilia and of two dorsal vertebrae of *Browniella africana*. Nat. size.  
 22. Right pubis of *Euparkeria capensis*. Nat. size.  
 23. Pelvis of *Mesosuchus browni*. Nat. size.  
 24. Pelvis of *Euparkeria capensis*. Nat. size.  
 25. Pelvis of *Ornithosuchus woodwardi*. About  $\frac{1}{2}$  nat. size.  
 26. Pelvis of *Gryponyx africanus*. Much reduced.

## 41. On some Cases of Blindness in Marine Fishes.

By G. E. BULLEN, the Hertfordshire Museum, St. Albans\*.

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Of recent years considerable attention has been given by numerous ichthyopathologists and fish-culturists to the sporozoic and bacterial diseases affecting those species of fish which in a live state form an article of commerce.

The important work of Hofer†, and the Monograph now appearing from the pen of de Drouin de Bouville‡, are perhaps two of the best known contributions of a general character upon the subject. There are, moreover, numerous more or less important works upon those organisms giving rise to disease: the Myxosporidia, for example, have received considerable notice from such investigators as Balbiani§, Thelohan||, Doflein¶, and Gurley\*\*, to quote but a few of the authors upon the subject.

Work which has been performed, even within the past decade, upon the bacterial aspect of fish diseases is of too extensive a character to be cited, however briefly, here. The same applies to Saprophytic and other fungoid growths attendant upon bacterial lesions.

The investigations of J. Hulme Patterson and certain others upon Salmon disease are well known and important contributions to economic science in this respect. But with the exception of certain papers by G. H. Drew and Patterson's findings, so far as they apply to Salmon installed in sea-water, most of the literature dealing with disease in marine fishes is confined almost entirely to the œcology of pathogenic organisms. For, whereas there is no inconsiderable amount of the literature directed solely to the pathology of freshwater fishes, there is at present a remarkable paucity dealing with those of marine habitat.

The present paper, therefore, is put forward largely with a view to associating the pathological aspect of certain forms of eye diseases observed in marine fishes with those already described, in more or less general terms, in the case of freshwater species.

\* Communicated by JOHN HOPKINSON, F.L.S., F.Z.S.

† 'Handbuch der Fischkrankheiten.'

‡ 'Les Maladies des Poissons d'eau douce d'Europe.'

§ 'Leçons sur les Sporozoaires,' Paris, 1884, etc.

|| 'Recherches sur les Myxosporidies,' Bull. Soc. France et Belgique, ser. 4, vol. v. Paris 1894, etc.

¶ 'Die Protozoen als Parasiten und Krankheit Serrigers,' Jena, 1901. "Studien zur Naturgeschichte der Protozoen," Zoologische Jahrb. xi. 1889, etc.

\*\* "Myxosporidia, etc." Rep. U.S. Commissioner for Fish and Fisheries, 1892. Washington, 1894.

The several subjects described hereinafter were received by the writer from the Superintendent of the Brighton Marine Aquarium, Mr. E. W. Cowley, to whom thanks are due. Acknowledgment of much assistance in the preparation of this paper is also accorded to Mr. John Hopkinson and to the late Mr. G. Harold Drew.

Hofer\* traces the progress of the more usual form of blindness in freshwater fishes in the following manner: ( $\alpha$ ) Corneal "cataract" due to injury or pathogenic bacteria attacking the integument; ( $\beta$ ) gradual necrosis of the cornea-epithel and outer surface of the cornea; ( $\gamma$ ) perforation of the cornea. Complications which may occur are "Keratoglobus" in the earlier stages, and Saprophytic growth attendant upon the bacterial lesions.

In the case of several freshwater fishes, the same author describes a not uncommon form of blindness due to parasites (*Diplostomum* larvæ), but of all the marine fishes which herein receive notice, none has been affected in this manner. Moreover, it may be recorded that no evidence of Saprophytic growth occurred on even the worst examples†.

### 1. *Traumatic Corneal Opacitis in a Conger Eel* (*Conger vulgaris*).

The subject of this note was a Conger Eel which measured 3 feet 7 inches. It had lived in the Aquarium for nearly six years, retaining complete health until November 1912, when, according to the Superintendent of the Aquarium, Mr. E. W. Cowley, it went completely blind within the space of a week. It was destroyed immediately, when, from an observation of its behaviour, both eyes appeared to have become wholly useless.

An examination of the head of this specimen showed that the right cornea-epithel was perforated in two places and the left in five, each perforation being just large enough to admit a seeker .5 mm. in diameter. Extensive penetration of sea-water followed probably by bacterial lesions had occurred throughout the under surface of the cornea-epithel, those on the left side extending to the adjacent epidermis of the gill-covers, destroying the colour-cells, and rendering the part affected opaque white. The eye itself, when superficially examined, was so completely dimmed as to render observation of the characteristic yellow iris difficult, except in strong light.

The term "corneal opacitis" would be somewhat loosely applied in this instance, since upon removal of the integument the cornea proper was found to be completely free from injury, and but slightly affected with opacitis.

\* *Op. cit.* p. 291 etc.

† For a determination of this fact the writer's thanks are due to Miss Lorraine Smith, of the British Museum.

The condition termed by Hofer \* "*Keratoglobus*," *i. e.* outward bulging of the cornea away from the pupil, did not affect either eye, the lenses retaining their normal position.

Blindness, therefore, in this instance was due apparently to mortification and bacterial lesions of the integument of the head passing over the eye attendant upon perforation of the cornea-epithel.

Hofer † remarks: "In the case of a fish weakened by disease, or in a dying condition, the organs of sight are deeply sunk in their orbits, whereas in a healthy fish the eyes somewhat protrude." In the present example this condition was wholly apparent, the eyes presenting the flabby appearance to be seen in a fish some hours after death.

It is highly probable, therefore, that perforation of the integument above the cornea, resulting in blindness, was largely due, in the present instance, to the susceptibility of the fish, already weakened by graver organic disease, to injury; and that incipient corneal opacitis may sometimes be taken as a diagnostic of other disorders.

## 2. *Corneal Opacitis in a Greater Weever* (*Trachinus draco*).

The chief difference between the condition of the eyes in the present example and that of the Conger Eel already described, lay in the fact that apparently no lesion of the cornea-epithel appeared to have taken place. The subject under consideration had lived for some years in the tanks at Brighton, and had attained the considerable measurement of  $15\frac{3}{4}$  inches. In this case partial blindness only had come about at the time when the specimen was examined. The left eye was less affected than the right, this showing a more or less evenly distributed film of dimness, as if the specimen had been immersed for a short time in weak formalin. The right eye, however, not only showed distinct spots of necrosis unevenly distributed throughout the surface of the cornea, but there was also a pronounced "*keratoglobus*." With reference to this latter feature, it may here be remarked that a gathering of aqueous humour in front of the pupil, causing the cornea to bulge outward to a considerable extent, may occur, doubtless as the result of concussion, in fish the eyes of which are otherwise apparently unaffected. At the Brighton Aquarium occasionally numbers of a shoal of mackerel may be observed with both eyes protruding in this way, but their undoubted lack of effectual vision appears in no way to interfere with their capability for maintaining position in a moving shoal. But it is a noticeable fact that they appear much thinner than their fellows consequent upon a more limited

\* *Op. cit.* p. 293.

† *Op. cit.* p. 290. The translations adhere as nearly as possible to the original text.

absorption of food. Not unfrequently, moreover, such examples present a certain broken-backed appearance, which, so it is stated by the attendant in charge of the tanks, is due to the fish, when first installed, persistently hammering themselves against the glass!

### 3. *Corneal Opacities and Cataract in Pollack* (*Gadus pollachius*).

The Pollack forming the subject of the present note were four young specimens ranging from  $7\frac{1}{2}$  to  $8\frac{1}{2}$  inches in length. At the time when they came under the writer's observation (in Sept. 1912) they had lived in the Aquarium, in a tank apart from other fish, for a period of about nine months. When first installed their sight appeared to be normal; but it seems that these particular fish had been taken on a position close inshore off Shoreham, where there is an outflow of chemical waste.

Mr. E. W. Cowley informed the writer that fish which were known to have come from this locality were as a rule refused for stock purposes, in view of the fact that, after a short period in the Aquarium, they invariably showed signs of disease. Hofer\* states: "Trout, etc., have been frequently attacked by perforation of the cornea and cataract through existing in waters impregnated with iron from drains"; and goes on to say, "It is not yet established whether these consequences are to be ascribed to iron salts in general or to any particular one." A lack of similar observation, viz.: the effect of industrial wastes, sewerage, etc., upon those marine fishes often frequenting estuaries and tracts of water in which such impurities are known to occur, prohibits any comparison. Yet it is a noticeable fact that the examples about to be described exhibit a form of blindness most frequently met with in various freshwater fishes (*e. g.* Pike, Perch, Carp, etc.).

At the time when the present specimens came under the writer's observation, they were without doubt totally blind, both eyeballs of each example presenting the opaque white appearance similar to that seen in the case of fish which have been boiled. The cornea in every case was but slightly affected, no apparent lesion being discernible on any part of the integument covering it. The general transparency, moreover, was considerably greater than it was in the case of either of the two preceding examples. On dissection it was found that the cornea protruded in front of the lens to a considerable extent (cir.  $2\frac{1}{2}$  mm.). A transverse section, taken through the centres of both eyeballs from two of the specimens, showed that the extent of necrosis attacking the interlocking fibres was practically the same, viz., equivalent to two-thirds of the entire diameter of the section. Vertical sections, *i. e.* from anterior to posterior aspect of the lens, showed

\* *Op. cit.* p. 291.

a slight increase on the anterior margin, the total extent, however, being slightly less than that observed in the transverse sections, amounting roughly to slightly less than half the diameter in affected tissue. The term "cortical cataract," as applied to the human subject, would perhaps aptly describe the condition observed when in its earlier stages\*.

The behaviour of these fish in the Aquarium is a matter deserving of some comment. Habitually they were observed to swim in mid-water, maintaining one position often for several minutes together, and seldom exhibiting much activity in movement. It is a somewhat remarkable fact, but one which the present writer, by an observation extending over several weeks, can personally vouch for, that on no occasion were any of the specimens seen to come in contact with each other, the sides of the tank, or the glass. Pollack with normal vision installed in an adjacent tank were easily attracted when a moistened finger-tip was rubbed rapidly up and down the glass causing vibration thereby, less freely by gentle tapping. The blind fish, even when situated within a few inches from the glass, made no effort to respond to this attraction.

When food, in the form of finely-cut fish, molluscs, etc., was offered, it was allowed to sink to the bottom and remain there for several minutes before a search after it was made. This took the form of a wholly haphazard grubbing about on the bottom, the fish often making a vigorous "bite" immediately beside a fragment, this operation being repeated until the morsel was secured. Although a sufficiency of food was placed in the tank daily, and on one occasion one individual fish was observed within the space of 15 minutes to secure three fragments of moderate size, all the specimens when examined post-mortem were found to be very ill-nourished and considerably below normal weight.

NOTE:—The writer is indebted to Mr. J. O. G. Ledingham, of the Lister Institute of Preventive Medicine, for the following report respecting the histological condition of the lens in one of the above specimens. This gentleman writes "I cut Celloidin sections of the fish's eye you sent to me in formalin. They were very difficult to cut owing to the fact that the lens proved to be completely calcareous. This was the only obvious lesion I could detect. I saw no micro-organisms in the sections; but, as you will understand, the sections were not satisfactory for the demonstration of micro-organisms."

\* *Vide* L. B. Harman, "Aids to Ophthalmology," p. 83.



## 42. Notes on Turacin and the Turacin-Bearers. By Sir ARTHUR H. CHURCH, K.C.V.O., F.R.S.\*

[Received May 26, 1913: Read June 3, 1913.]

In bringing, at the suggestion of the Secretary, these notes before the Zoological Society I have a threefold object. First, to give a summary history of our knowledge of the occurrence in the Plantain-eaters of turacin, the remarkable (I may say, the unique) decorative pigment which is distinctive of the three genera *Musophaga*, *Turacus*, and *Gallirex*; secondly, to describe the properties of the pigment; and, thirdly, to correct some prevalent errors on the subject of turacin—errors due in part to initial mistakes made by observers, and in part to incorrectness in the transmission of facts by copyists.

Although the earliest observation as to the occurrence in certain Turacoes of a singular red pigment seems to be assignable to the year 1818, yet I have not found any publication of the fact by the original observer until more than half a century later. Then, on January 17th, 1871, a Corresponding Member of this Society, M. Jules Verreaux, described at a meeting his observations and experiments on the subject, referring them back to the year 1818. Verreaux's remarks are to be found in the 'Proceedings of the Zoological Society' for 1871 (pp. 40 *et seq.*); they refer to the *Corythaix albicristata* of Strickland. Many of these Turacoes were met with in the Knysna district of the Cape of Good Hope, and were carefully observed by Verreaux. He noticed that, in the torrential rains that prevailed at the time, these birds left the tree-tops and sought refuge in the dense lower branches. One bird, which he had seized by the wing, escaped, and he says that great was his surprise to see the inside of his hand coloured a blood-red. Some days later the experiment was repeated with three more specimens caught in a soaked condition; it was easy to remove the pigment from the feathers by friction and to reduce them to a pale rose hue. What M. Verreaux here adds to his observation as to the solubility of the red pigment in rain-water is, I venture to think, hard to believe. He wrote in French, and I give his own words:—"Mais ce qui nous surprit le plus, fut de voir cette même coloration rouge vif revenir dès que l'oiseau était complètement séché. Nous avons renouvelé cette opération deux fois par jour, et chaque fois nous avons eu le même résultat." M. Verreaux further extends his observations to other species of Turacoes, finding in them the same colouring-matter, possessed of the same mobility and of the same power of renewal when the feathers became dry. He even affirms such recovery of colour in the case of birds that have been killed as well as of those that have been captured. One cannot

\* Communicated by the SECRETARY.

but ask, how is it possible for a mature feather to be again supplied with this localized red pigment after it has lost its original charge and after the vessels in the quill have dried up, their function having been fulfilled? The opinion of V. Fatio, as to an oil making its way up the mature feather and dissolving and distributing pigmentary deposits already present, does not apply to turacin which is insoluble in oily media. As to the case now being considered, I have not been able to obtain any confirmation of this renewal of the pigment (apart from a moult) from any trustworthy naturalist. The late J. J. Monteiro, the late Dr. Benjamin Hinde (of Bathurst on the Gambia), and many other competent observers of these birds in their native haunts and in captivity have expressed themselves strongly on this point. It may be admitted that in the folded pinion which has had its pigment moved by soaking, some of the red solution may travel from the feathers beneath to the surface as it dries; thus we should have a case of transference of pigment, not of its renewal.

Amongst those who, after Verreaux, have observed this want of fixity in the red pigment of the Turaco I may name the late Rowland Ward, the late W. B. Tegetmeier, also J. J. Monteiro and Dr. B. Hinde. The last-named, in a letter dated May 1865, said the moment soap touches the feathers the colour runs, although it is difficult of extraction by pure water. But he added "the birds which I sent home washed themselves nearly white in the water given them to drink." In my memoir of 1869, I mentioned Mr. Tegetmeier as having introduced the subject now being discussed to my notice. His own attention had been drawn to the matter by a correspondent of 'The Field,' who sent him a washed-out feather. Mr. Tegetmeier forwarded this feather to me and asked me to ascertain if there were any possibility of its having been dyed.

Such, in brief, was the position of the problem when in 1866 I began my researches. The chief results of these were published in the Phil. Trans. of 1869 and 1892, while in 1894 a Friday Evening Discourse in the Royal Institution presented a digest of the whole enquiry \*. Although it would be unbecoming in me, a chemist, to enter into classificatory questions before a company of zoologists, I may venture to remind you that, according to many systematists, the Order Cuculiformes includes two suborders of equal rank, the Cuculidæ or Cuckoos and the Musophagidæ or Plantain-eaters. The former is an extensive suborder and cosmopolitan in range, while the latter contains less than 40 species and is confined to the Ethiopic region of Continental Africa. Of

\* "Turacin, a new Animal Pigment containing Copper," 'Student,' i. (1868) pp. 161-168; with a coloured plate.

"Researches on Turacin, an Animal Pigment containing Copper," Phil. Trans. clix. (1869) pp. 627-636 (with 4 figs. of spectra).

"Researches on Turacin, an Animal Pigment containing Copper," Part II., Phil. Trans. clxxii. A. (1892) pp. 511-530 (with 9 figs. of spectra).

Proc. Roy. Inst. xiv. (1894) pp. 44-49.

the six genera of Musophagidæ three contain the crimson pigment which I named turacin. These are:—*Musophaga*, 2; *Turacus*, 21; *Gallirex*, 3; or 26 turacin-bearers in all. The three remaining genera from which turacin is absent are:—*Corythæola*, 1; *Chizærhis*, 4; and *Gymnoschizorhis*, 2; or 7 in all. There are two remarks that may be interposed in this connection. The first is that the crimson pigment is identical in all the species, and occurs not only in from 6 to 18 of the primary and secondary pinion-feathers, but also in all other similarly-coloured feathers or parts of feathers which are found on some of these birds—for example, in the head-feathers of *Musophaga violacea*, in the crest-feathers of *Turacus donaldsoni*, *T. fischeri*, and *T. meriani*, and in the head-feathers of *Gallirex johnstoni* behind the crest. The second remark refers to the pinion-feathers of three out of four species of *Chizærhis*, which have white patches bare of any pigment pretty much in the same position as the crimson patches in the turacin-bearers, although mostly confined to one side of each shaft—a curious coincidence, at all events.

I may now turn to the properties of turacin. We have already seen that it is soluble in water. Not, we may add, in hard water, but in clean rain water or, better, in distilled water. It is still more easily dissolved by weak alkaline liquids, extremely dilute ammonia being the best solvent. From this crimson solution, the colouring-matter, the turacin, is precipitated as gelatinous flocks on neutralization by hydrochloric or other acid. The flocks that separate when collected and dried form a deep red amorphous mass, crimson by transmitted light when in thin layers, but exhibiting a surface-lustre of a purplish hue, not unlike that reflected from crystals of potassium permanganate. Thus the appearance of solid turacin cannot be said to be accurately described when it is spoken of as “a metallic red or blue powder,” as in the Enc. Brit. 11th ed. vol. x. p. 226 a. Turacin is insoluble in alcohol, ether, chloroform, petroleum-spirit, benzol, and the usual solvents of resins and oils. In order to obtain it in a pure state special procedure is required to prevent its contamination with the natural oil of the feathers, while it is not possible to free it completely from all traces of non-essential mineral matter. The action of heat on dry turacin presents several points of interest. It suffers no change at a temperature rather above that of boiling-water, but at or near the boiling-point of mercury it is profoundly modified without loss of weight and becomes insoluble in alkaline liquids. If this altered turacin be now exposed to a high temperature in the presence of air its combustible constituents burn away, leaving a black ash, amounting in the purest samples to about 9·8 per cent. of the original weight. This ash consists almost entirely of oxide of copper, the amount corresponding to at least 7 per cent. of that metal in the turacin itself. Here again the statement in the Enc. Brit. (*loc. cit.*) needs correction, for this is a fixed percentage, not one that varies from “5 to 8.” In further describing the action of heat upon dry turacin it

must be mentioned that this colouring-matter, when suddenly and strongly heated, yields a volatile, red, copper-containing derivative, which, undissolved by weak ammonia-water, is not only soluble in, but may be crystallized from, ether. It is the vapour of this substance catching fire which gives rise to the green flame so conspicuous when a particle of turacin is heated in the air. If I were discussing the nature and relationships of turacin from a chemical view-point, much would have to be brought forward as to its composition and probable formula. Here let it suffice to say that analysis gives these percentage-numbers:—

Carbon .....	53.69
Hydrogen .....	4.60
Copper .....	7.01
Nitrogen .....	6.96
Oxygen .....	27.74

These figures, though deduced from many careful determinations, do not lead unmistakably to one definite empirical formula. With a colloidal compound like turacin, which does not admit of purification by distillation or crystallization, there is always the chance of a disturbing factor being present in the shape of a trace of some impurity. Possibly such an expression as  $C_{40}H_{38}N_3CuO_{16}$  is worth suggesting. In this the ratio of nitrogen to metal is as 4:1, the same ratio which occurs in hæmatin from blood between nitrogen and iron, and between nitrogen and magnesium in some chlorophyll constituents and derivatives. With all these bodies turacin is also brought into relation when its absorption-spectrum is considered, especially in regard to that broad band in the violet and ultra-violet (between the lines *h* and *M*) which is common to all these colouring-matters, and which was figured and described by the late Prof. Arthur Gamgee in a paper read before the Royal Society in 1896—a paper in which the author confirms my results, especially those relating to the discovery of turacoporphyrin.

The spectrum of turacin may now engage our attention: in the feather itself the pigmented web shows two broad bands, one with its centre at wave-length at or near 585, the other with its centre near 538. A solution in water containing a trace of ammonia shows the same two bands somewhat shifted towards the violet end of the spectrum; there is also seen a very faint band about the solar line *F*, but nearly as broad as band No. 2. When turacin which has been precipitated from its alkaline solution by strong hydrochloric acid is again dissolved in weak ammonia-water, and the solution spectroscopically examined, a narrow and faint fourth band situated on the less refrangible side of *D* makes its appearance. It is almost certain that this band is due to an alteration-product of the original turacin. The two well-marked bands, as they are shown when examining a feather with the spectroscope, closely resemble those of the oxy-hæmoglobin of the blood; while the corresponding bands seen in the

spectrum of an alkaline solution of turacin are not unlike those of CO-hæmoglobin. However, the absorption-spectrum of turacin is sufficiently characteristic to enable one to use it as a criterion of the presence of this pigment in the red feathers of birds. So when Dr. C. F. W. Krukenberg announced the occurrence of turacin in a species not belonging to the Musophagidæ, and not even African, it became necessary to test the assertion. The bird in question is a Cuckoo from the Philippines, *Dasylophus superciliosus*. I obtained a skin, then an assurance of identity from the Bird Department of the British Museum. I removed the sparse red feathers from the head of this Cuckoo and submitted them to spectroscopic scrutiny. They did show an absorption-band, but it was situated midway between the two bands of turacin. Moreover, the colouring-matter, which is orange-red, not crimson, cannot be extracted by ammonia and contains no copper. Hitherto, therefore, turacin has not been found to occur outside the Musophagidæ. It is right to mention here that Dr. Krukenberg's statement as to its occurrence in a *Dasylophus* was made in consequence of a report addressed to him at his request by the authorities of the Senckenberg Museum in Frankfurt, and was not the result of an experiment made by himself\*. It has unfortunately found its way into various articles and books, e. g. Enc. Brit. x. p. 226 a, where we read "But turacin is not, as was supposed, confined to the feathers of the Plantain-eaters, since it has been obtained from a Cuckoo, *Dasylophus superciliosus*." I have been able to secure a threefold disproof of this statement, for although the occurrence of this pigment in any bird other than a Plantain-eater seemed unlikely, the closely-allied Cuckoos might have supplied an instance.

The occurrence of so large a percentage of copper as 7 in isolated turacin needs a word of comment. It does not imply a large amount of this metal in the plumage of a single bird; a high estimate gives less than 14 of a grain of the metal. And it must be remembered that many recent analyses of vegetable and animal matters show the wide distribution of copper in both kingdoms. Two of the latest researches in this direction were made by Mr. J. W. Dougal† in 1911 and by M. B. Guérithault in 1912‡. In fact, there is no difficulty in accounting for the presence of copper in Turacoes and for its amount.

I purposely exclude from the present paper any discussion of the curious green pigment named turacoverdin by Krukenberg; of the relationships between hæmatoporphyrin and the turacoporphyrin obtained from turacin by the action of acids; and of the supposed synthesis of turacin by treating hæmatoporphyrin with an ammoniacal copper solution.

\* C. F. W. Krukenberg, Vergleichend-Physiologische Vorträge (1886), Bd. i. p. 152.

† Pharm. J. 1911 (4) xxxii. pp. 405-7.

‡ Bull. Sci. Pharmacol. 1912, xviii. pp. 633-639.

43. Observations on the Anatomy of the Shoe-bill (*Balænicæps rex*) and allied Birds. By P. CHALMERS MITCHELL, M.A., D.Sc., LL.D., F.R.S., Secretary of the Society.

[Received and Read June 3, 1913.]

(Plates LXXX.-LXXXIII.\* and Text-figures 119-132.)

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In the end of June, 1912, a young example of the Shoe-bill (*Balænicæps rex*) arrived at the Gardens as a gift from the Sirdar, Sir Reginald Wingate, G.C.V.O., Honorary Member of the Society. It was not quite adult, but stood between three and a half and four feet in height. It was placed in a warmed enclosure communicating with a grassy paddock containing a small pond, and it fed well, although its appetite was small, on fish, frogs and pieces of meat. It appeared to thrive through the winter, but in the end of March, 1913, it showed difficulty in breathing. It was removed to the Sanatorium and kept for a few days in a warm, moist atmosphere, but died. The *post mortem* examination showed the presence of mycosis in the lungs, although not in sufficient quantity to cause mechanical obstruction to respiration, and the interior of the larynx and bronchi was nearly free, but subsequent microscopic examination by Mr. Plimmer, F.R.S., the Society's pathologist, revealed extensive infiltration of the tissues by the mould. As Dr. Beddard, the Society's Prosector, was engaged on other work, I gladly took the opportunity of making some observations on the anatomy of this rare bird, and give the results here. My work was to a certain extent limited by the necessity of not injuring the skeleton, which was destined for the British Museum (Natural History). Certain portions of the viscera were sent to the Museum of the Royal College of Surgeons.

I am indebted to my colleague Mr. D. Seth-Smith, the Society's Curator of Birds, for leave to reproduce on Plate LXXX. the excellent photograph of this bird, which was an immature male.

*Pterylosis*.—A. D. Bartlett (1) discovered and described the powder-down patches, and Professor Giebel (21) has written a

\* For explanation of the Plates see p. 703.



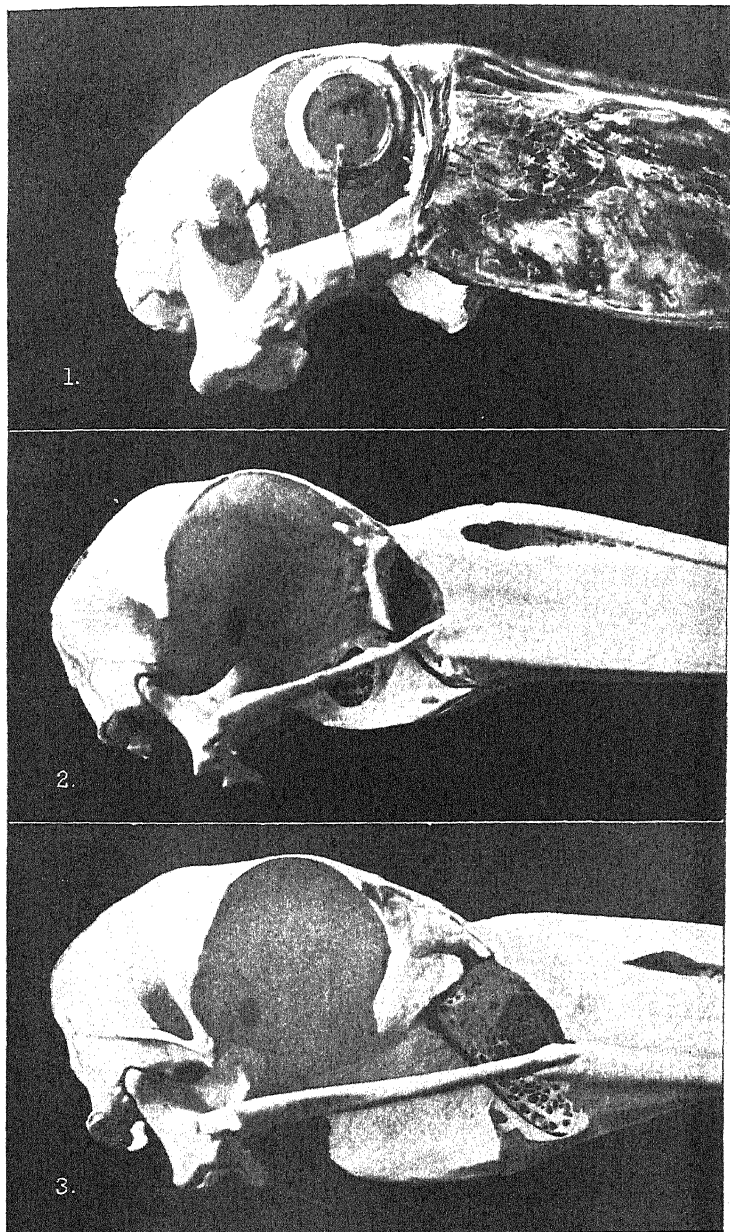
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D. Seth-Smith, photo.

BALENICEPS REX.





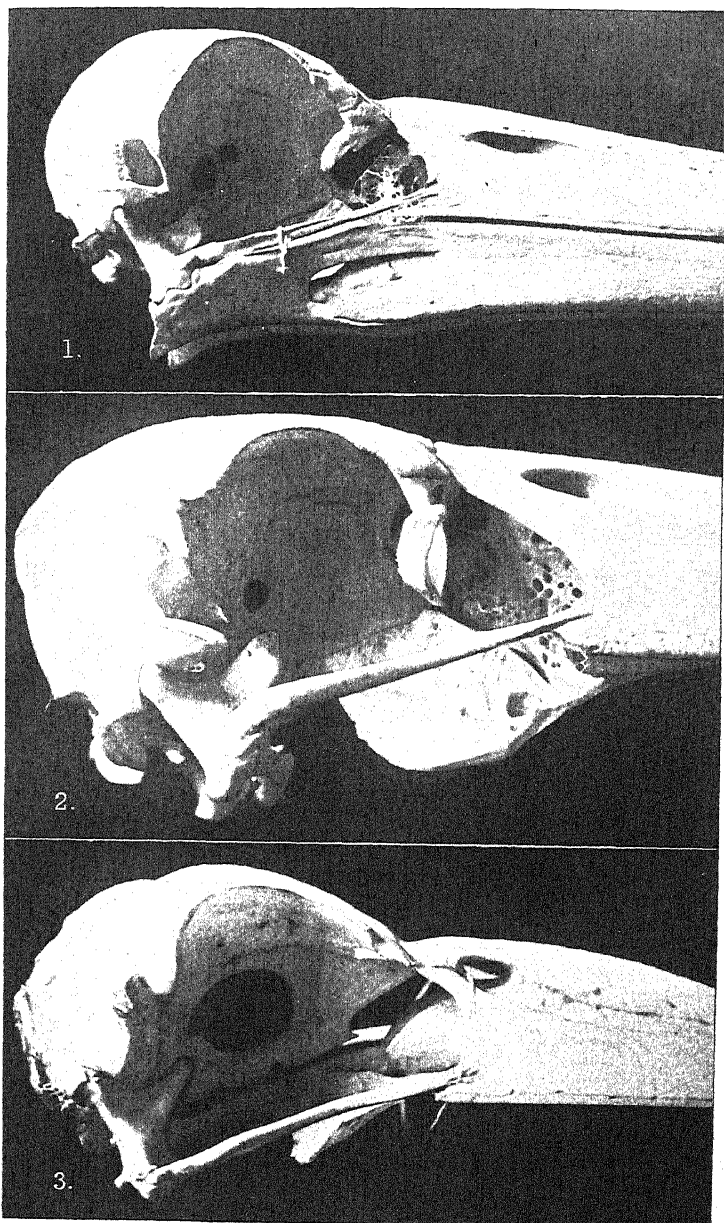


D. Seth-Smith, photo.

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SKULLS OF: 1. BALÆNICEPS. 2. SCOPUS. 3. XENORHYNCHUS.





D. Seth-Smith, photo.

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SKULLS OF: 1, DISSURA. 2, TANTALUS. 3, CANCROMA.



careful account of the external characters and pterylosis, but fortunately I finished my examination and notes of the pterylosis before having the opportunity of consulting Professor Giebel's paper, and find that my observations and inferences follow his very closely.

The down feathers are distributed practically uniformly over the pterylæ and the apteria as in Steganopods and Storks, whereas in *Scopus* and Herons they are found only on the apteria. The oil-gland has a tuft of feathers as in nearly all the members of the group. The contour feathers have a small aftershaft; this structure is present in Herons and *Scopus*, variable and sometimes absent in Storks.

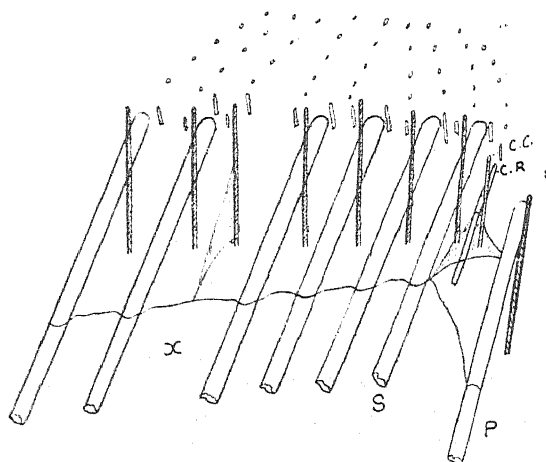
The feathered tracts generally are in marked contrast with those of Herons and resemble those of Storks in being relatively wide and fading off into the apteria, those in Herons being remarkably narrow and very sharply defined at their lateral and posterior edges. The neck is continuously feathered for almost the whole of its length, and shows no trace of the long lateral apteria characteristic of Herons and present in *Scopus*. Far back, near the base of the neck, there is a lateral space at each side. The spinal tract forks between the shoulders, leaving two parallel bands of feathers continuous with the neck area, and separated by a wide median apterion. These dorsal bands are wider than those of Herons and cease about the level of the axilla. Parallel with them at each side is a very broad and strong humeral tract, wider even than in Storks and much wider than in Herons. The dorsal tracts reappear again as a narrow diamond-shaped band, weaker in the middle line, and stretching between the powder-down patches to the oil-gland. The powder-down patch at each side is an enormous, elongated oval area extending from a little way behind the axilla to the rectrices, and reaching some way down the side of the rump. The patches are separated in the middle line. The feathers are long, very thickly set, and break down into a yellowish powder. When the bird had been in spirit, they formed unpleasant, greasy masses. Their discovery led Bartlett to associate *Baleniceps* with Herons as opposed to Storks. As, however, there are only two patches in *Baleniceps* as compared with four to six in Herons generally, eight in *Cancroma*, as they are absent in *Scopus* and exist in many other birds, e. g. *Eurypyga*, *Rhinochetus*, *Mesites*, some Tinamus, Birds of Prey, Parrots, and Goatsuckers, it is difficult to attach any systematic weight to their presence. Nitzsch's observation that they may disappear with age (e. g. *Gypaëtus*) still further destroys their systematic importance.

The femoral tracts bordering the powder-down patches are rather badly defined. The arrangement on the ventral surface is almost identical with that given by Nitzsch for *Ciconia*. The median apterion is rather indefinite except at the base of the neck and near the vent. On each side of it is a very broad feathered tract.

The rectrices are 12 in number as compared with from 8 to 12 in Herons, and 12 in *Scopus* and Storks.

The primary quills of the wing are 11, not 10 as Giebel states. Of these six are on the metacarpal, three on phalanx 1 of digit II and two on phalanx 2 of digit II, the last being much smaller than the others. There are 11 in Herons, 10 in *Scopus* and 11 or 12 in Storks. There are 19 secondaries as compared with 11 to 18 in Herons and 14 to 25 in Storks.

Text-fig. 119.



Wing-structure of *Baleniceps*.

Diagram of the distal secondary quills and coverts, showing the diastataxic condition. Right wing; external view. The quills are in outline, the major coverts are shaded; the transverse rows are represented by dots, showing the insertion.

- |                     |                    |
|---------------------|--------------------|
| S. First Secondary. | C.R. Carpal remex. |
| x. Diastataxic gap. | P. First Primary.  |
| C.C. Carpal covert. |                    |

In the figure (text-fig. 119) I give a diagram of the distal secondaries, showing the arrangement known as "aquintocubital" until W. P. Pycraft and I showed simultaneously (28, 36) that it was not due to the loss of a secondary feather, after which my term "diastataxic" has been used. The major coverts are inserted proximally to the quills and cross over them, and this arrangement is repeated in the case of the degenerate carpal covert and carpal remex, whereas the major coverts of the primary quills are distally placed. The diastataxic gap is very evident and the major covert, which occupies the gap, is tied down to the membrane supporting the quills by a special slip. In the same fashion the carpal remex has a membranous slip supporting it.

There is nothing peculiar in this arrangement; the diagram resembles closely the similar diagrams that I have given for other diastataxic birds (e.g., 32, fig. 23). There is some difference of opinion as to whether the secondary quills, major and minor coverts, and the feathers nearer the outer border of the wing represent horizontal or transverse series. Most writers, following the obvious lead given by the quills and major coverts, have preferred to regard the rows as horizontal. I have taken the other view, seeing in the quills merely the enlarged members of the transverse rows which happen to lie along the margin of the wing and to have become the flight feathers, and the points of insertion of the feathers in the plucked wing have always appeared to me to lie in transverse or rather diagonal rows stretching upwards from the quills and reappearing on the under side of the wing in the feathers with reversed surfaces. These diagonal rows were plain in the wing of *Balaniceps*, but I was surprised to find what I have not noticed in any other bird, although I am by no means prepared to say that it does not occur, that there was a transverse row too many. The row corresponding to the carpal covert and remex curved upwards and backwards; the next most proximal row had a similar curve and belonged to the distal secondary quill; then there appeared to be an extra row in front of, and not behind the second secondary quill. More proximally the rows were in regular correspondence with the quills and gradually changed their inclination. I tried to correlate the arrangement with what W. P. Pycraft has called the "intercalary row" (a transverse row which in his opinion is associated with the mode of origin of the diastataxic gap by "faulting" of the horizontal rows in development), but was unable to make anything of it. No one appears to have published any observations on the theory of diastataxy since Pycraft and myself. In our communications to the Linnean Society (28, 36) we showed that the condition was not due to the loss of a feather, Pycraft arguing from ontogeny and I from comparative anatomy. I showed that whereas most pigeons were diastataxic, a few were eutaxic and had arrived at this condition by a secondary closing of the diastataxic gap. I also showed that the eutaxic pigeons were in other respects more specialized than their diastataxic allies. In later papers (29, 31) I showed that similar conditions existed amongst Kingfishers and amongst Gruiform birds. The general inference seems to be clear: that the eutaxic groups are more specialized birds and that in association with their general specialization they have lost the primitive diastataxic arrangement. My argument, however, may be anatomically sound with regard to the groups presenting both conditions, and yet not applicable to birds generally. All birds may have been eutaxic originally; certain families may have become diastataxic, and amongst these certain members may have secondarily reverted to the eutaxic condition. Pycraft assumes that the eutaxic condition was primitive, and if he be

correct, my facts would have to be interpreted according to the alternative I have just given. But I am not convinced by Pycraft's deduction from his observations on the ontogenetic changes in the wing. The development of the individual is partly a process of latent differences becoming visible, and because a diastataxic bird appears to be eutaxic at a very early stage, it does not follow that eutaxy was primitive. I am much more impressed by the general view that passerine birds are plainly the most specialized of all birds, that they are eutaxic, and that the members of diastataxic groups which have become eutaxic are in other respects most passerine-like. In the absence of any convincing theory of the phylogenetic origin of diastataxy, all peculiarities in the arrangement of feathers are interesting and may come to have significance, and so I have digressed with regard to the wing of *Baleniceps*.

It is plain that the pterylosis of *Baleniceps* is of the same general character as that in Storks, Herons and *Scopus*. To my eye, the general appearance and coloration suggest affinity with Herons rather than with Storks. The sedate habit of standing silently on any little eminence, the absence of the habit of clattering with the beak, which we noticed in the Gardens, and the reported heron-like bending of the neck in flight, confirm this view. But the actual details of the feathering do not confirm it; without any doubt, so far as pterylosis can be relied upon as indicating affinity, *Baleniceps* is more Stork-like than Heron-like.

Petherick, however, (34) has recorded that the young ran about with extended wings making a "rattle-like noise produced by the snapping of their bills."

*Foot and Claw.*—The hind toe (hallux) is usually carried pointing backwards, but is freely movable in every direction. It is on the same level as the other toes, as in Herons and *Scopus*, not slightly elevated as in Storks. There is no trace of a web uniting any of the toes, whereas in Herons and *Scopus* there is usually a distinct web uniting the third and fourth toes, and in Storks all three front toes are united by web.

A good deal of confusion, which I am able to dispel, has crept into the literature with regard to the condition of the claw of the third digit of the foot. It is well known that the inner edge of this claw is pectinated in Herons and unbroken in Storks. Professor Reinhardt (37, p. 378) stated that *Baleniceps* had not a comb on the middle claw, adding that this absence afforded "a strong warning not to class it with the Boatbill, as this peculiar serrature never fails in any member of the Heron tribe." Gadow (16, p. 137) divided the Ardeæ into Family 1. Ardeidæ, dividing the latter into the sub-families Ardeinæ and Balanicipitinæ, mentioning as a character of the former "Mittelkralle gezähnt," and of the latter "Mittelkralle nicht gezähnt," and Family 2. Scopidæ, including in the definition of the latter, "Mittelkralle gezähnt." Beddard (3, p. 289) cites Professor Reinhardt's opinion

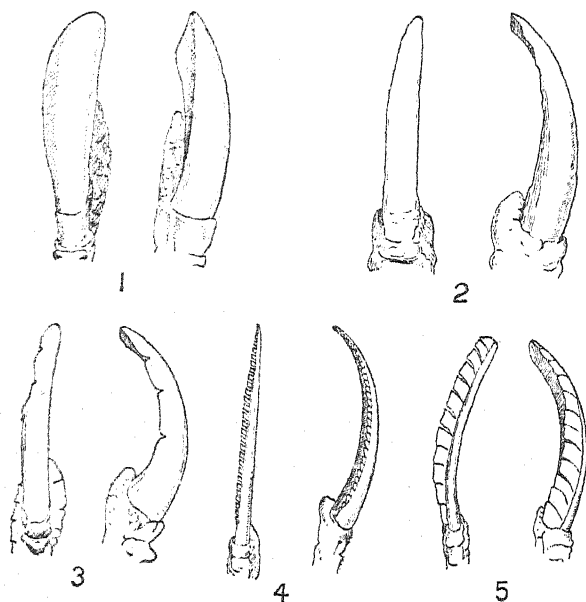


that "as the middle claw is not pectinated, *Balæniceps* cannot be referred to the Herons," adding "Professor Reinhardt would associate *Balæniceps* particularly with *Scopus*," but omitting to mention that in the same paper Reinhardt stated that the claw was pectinated also in *Scopus*. Mr. A. H. Evans (8, p. 87) divides the Sub-order Ardeæ into the Families Ardeidæ (in which he places *Balæniceps*) and Scopidæ, and states that in the Sub-order the "claw of the middle digit is toothed on the inner side, save in *Balæniceps*." It is surprising that as Gadow, Beddard, and Evans all seem to have thought the matter worth comment, they should have omitted to notice Giebel's (21, p. 351) very definite description. Giebel stated that in the two examples of *Balæniceps* he had examined the pectination was clear and sharp, the actual teeth being not so small, numerous and deeply incised as in *Canceroma* and *Nycticorax*, but larger, separated by wider intervals, and, beginning at the point, reaching nearly the middle of the nail. He described them as closely corresponding with those of *Scopus*, adding that the latter had not received full attention from systematists.

I hope that the drawings reproduced in the figure (text-fig. 120), which were made by Mr. Berridge from the actual specimens, will explain the matter. In a large number of birds belonging to different groups, the claw of the third toe of each foot is not symmetrical about the middle line; the ulnar or abaxial edge is relatively straight, and the radial edge, that nearest the body, is curved out into a sharp-edged scoop. The foot of the White Ibis (fig. 120, 1) shows this condition well. In *Balæniceps* (fig. 120, 2), owing to the lateral compression of the claws, the scooped edge is not quite so conspicuous in a dorsal or lateral view, but it exists. Moreover, as Giebel described, this sharp edge is marked by a few serrations between each of which there is rather a wide space, but which are so conspicuous on the claw that they can be felt not only along the edge but as slightly ribbing the surface. In *Scopus* (fig. 120, 3) the condition of the claw is almost exactly similar to that in *Balæniceps*. In the example I examined and from which the drawing was made the serrations were cut a little deeper than in *Balæniceps*, but according to Giebel, in the specimens of *Balæniceps* he examined, the serrations were deeper. The exact amount of serration is no doubt subject to individual variation. In the corresponding claw of the left foot of the Umbre I examined, each tooth was much narrower and more pointed, resembling the *Balæniceps* condition more closely. In the Little Bittern (fig. 120, 4) and in the Goatsucker (fig. 120, 5), the teeth are much more numerous, regular, smaller and more closely set together, and when the comb is highly developed, it may stand out conspicuously from the edge of the claw, sometimes by not being developed along the whole edge, and sometimes because the thin edges of the teeth give the comb a yellow semi-transparent coloration, readily visible against the duller and more opaque unbroken part. Almost every gradation

between the sharp unbroken edge and a fully formed comb can be found in nearly allied birds, and it must be a matter of individual taste at what particular stage of elaboration it is possible to describe the serration as a comb. It is at least certain that *Baleniceps* cannot be separated from *Scopus* and the Herons and associated with the Storks because of absence of pectination.

Text-fig. 120.



Modified Claw in some birds.

Claw of the third toe of the right foot, in each case the left-hand figure showing the dorsal aspect, the right-hand figure the axial side.

1. Red-billed White Ibis (*Eudocimus longirostris*).
2. Shoe-bill (*Baleniceps rex*).
3. Tufted Umbre (*Scopus umbretta*).
4. South American Little Bittern (*Butorides cyanurus*).
5. Nacunda Goatsucker (*Podargus nacunda*).

It seems obvious, however, that the formation of a comb falls in the category of what I have termed "multiradial apocentricities," modifications from the normal or primitive type, which as they have occurred repeatedly and independently, afford no information as to the systematic position of the animals in which, they occur. By the kindness of Mr. Seth-Smith I have looked through a number of the skins in the collection of the Society, and with the assistance of Mr. Ogilvie-Grant a still larger number

in the Bird Department of the British Museum. Most of the Steganopods have a scoop-like edge forming a primitive stage like that shewn in the figure (fig. 120, 1), but some of them, for instance the common Cormorant, have a well-formed comb. The small claws of Storks seem to have no trace even of the initial asymmetry, but Ibises are certainly more nearly allied to Storks than to Spoon-bills, and although the White Ibis (fig. 120, 1) has only the scoop-like edge, the Glossy Ibis (*Plegadis falcinellus*) has a well-formed comb. *Eurypyga* and *Rhinocetus* have the curved edge but no serration; *Cursorius*, *Dromas* and *Glareola* have well-marked combs. Among the Strigidae, *Scops* and some of the smaller owls have the curved cutting-edge without serration; *Ketupa* is in the same condition. *Bubo* has a well developed cutting-edge with a few slight serrations; *Strix flammea* has a well-marked comb occupying the upper part of the edge of the claw. By a curious accident of nomenclature I was led to examine some of the Birds-of-Paradise. Fürbringer mentions *Falcinellus* as a genus in which the claw is pectinated, and as I had forgotten that that name had been used for a genus of Ibis, and knew that it was used for a Bird-of-Paradise, I examined the latter, and found that the claw in the Rifle-birds usually showed a sharp cutting-edge and that occasionally (e. g. *Ptilorhis* and *Epimachus*) there were slight nicks in it.

H. R. Davies (7, p. 368) in discussing the function of this organ remarks that the "pectinated claw should not be regarded as a structure peculiar to nightjars, owls, herons, cormorants and gannets, and different from anything found in any other bird, but merely as a highly modified form of a structure found in a less modified form in many birds." There seems to be no doubt but that the chief use of the modification of the claw is for scratching, possibly for removing parasites, and its presence may be compared in a general way with the condition in the mammalian Dassies, in which all the digits are protected by flat nails, except the inner digit on each hind foot which is provided with a sharp claw used in scratching.

*Rhamphotheca*.—The horny covering of the beak is compound in *Balaeniceps*, the premaxillary portion being separate, as in *Scopus*. In Storks and Herons it is simple. The edge of the horny lower jaw is delicately serrated.

*The Syrinx*.—This has been studied and figured by Beddard (3), and I have to add to his description only that the first two incomplete bronchial rings are partly calcified, that the brouchi are relatively rather long, and that the distal bronchial rings are practically complete. On the most careful examination, I could find no trace of anything corresponding to what Beddard took to be fibrous vestiges of the intrinsic muscles present in Herons; they were as completely absent as in Storks. I cannot follow Beddard, moreover, in his view that the structure of the syrinx is "conclusively in favour of regarding *Balaeniceps* as a Heron and not as a Stork." So far as the syrinx of *Balaeniceps*

agrees in structure with that organ in Herons and in *Scopus*, it conforms not with a structure that is specially Ardeine, but with one that is found in so many different groups that Beddard himself has spoken of it as the typical avian syrinx. Storks, as he himself has shown, display a series of stages most conveniently regarded as degenerations in different degrees from the typical avian syrinx. *Baleniceps* shows degeneration, if not complete absence of the intrinsic muscles; it has not degenerated so far as most of the Storks, but the fact is that as there is no typical ciconine and no typical ardeine syrinx, the condition in *Baleniceps* affords no clue to its relationship with either of these groups.

*Carotid Arteries*.—The normal condition, present in a large number of birds of different groups, and what development and comparative anatomy would seem to indicate as the primitive avian condition, is the presence of both right and left carotids, separate and well developed. This is the condition usual in Steganopods, Herons, *Scopus* and Storks. I was surprised therefore to find that only the right carotid was present in *Baleniceps*, and although I searched carefully, I could find no trace of even a degenerate left artery. I do not attach systematic importance to the condition of the carotids, as this often varies within a Family. In *Botaurus*, for instance, the two carotids fuse very close to their origin, and in another member of the Ardeidæ (*Ardeletta*) the right carotid only is present.

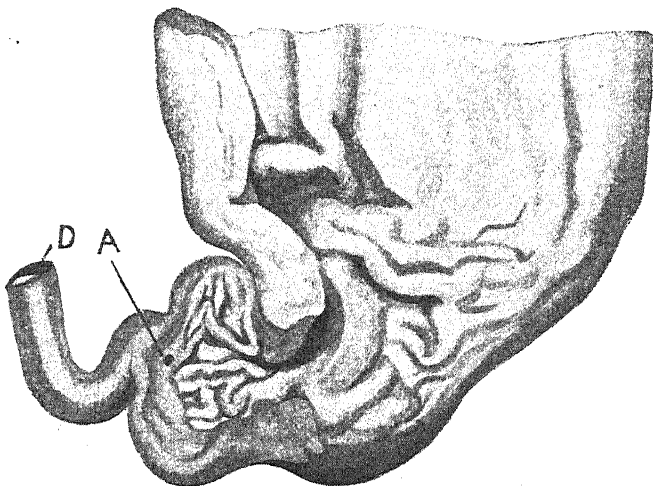
#### ALIMENTARY CANAL.

*The tongue* is only a vestige as in Storks, *Scopus* and *Cancroma*, whereas it is long in Herons.

*Stomach*.—The stomach is a capacious, elongated, rather thick-walled sac, extending posteriorly in the line of the œsophagus, from which it is to be distinguished externally only by a gradual increase of calibre. Distally it ends in a blunted angular point, and just proximal of this it gives off, on the right side, a globular chamber from which the duodenum arises (text-fig. 122, P, p. 657). Externally there is no trace of any specially tendinous area, and no constriction to mark off a proventriculus from a gizzard. The interior of the stomach, including the chamber at the pyloric end, is lined with a thin but well-marked layer consisting of the hardened secretion of the gastric glands. The cavity of the stomach is distinctly marked off from that of the œsophagus by the corrugated edge of the membrane-like layer of secretion. The general cavity is sharply marked off from that of the pyloric chamber by a well-marked constriction (text-fig. 121). The greater part of the interior of the larger chamber is marked by longitudinal folds, but towards the posterior end these pass into irregular corrugations which are continued into the pyloric cavity. When the internal surface is scraped and the wall squeezed, the large glandular apertures may be seen to be distributed over the whole area of the stomach and pyloric cavity,

with a slight tendency to be arranged in longitudinal bands, but there is no indication of separation into a glandular proventriculus and a muscular gizzard, and no trace of aggregation into specialized patches or areas.

Text-fig. 121.



Stomach of *Baleniceps*.

The distal end of the stomach and the pyloric chamber have been laid open to show the constriction separating the general cavity from the cavity of the pyloric chamber and the minute aperture, A, into D, the duodenum.

We have to recognize in the first place that the absence of distinction between proventriculus and gizzard gives no clue to the position of *Baleniceps* in the assemblage of Pelargo-Colymbiform birds. F. S. Leuckart (23) discussed this formation in 1841, citing the earlier authors, such as Blasius and Cuvier, who had called attention to it, described it in a number of birds and associated it with diet. It is tempting to associate such an undifferentiated condition with a primitive structure, but I do not think that such a view is tenable. At one time I myself thought that it might be possible to derive information useful for systematic purposes from the condition of the stomach, and I examined and made drawings of the organ in a large number of birds. But throughout the group, from Divers to Eagles, the extent to which gizzard may be separated from proventriculus by external or internal configuration, by specialization of muscle and tendon, or by aggregation of glandular areas, varies so irregularly as to suggest adaptation to habit rather than genetic tendency. The typical fish-eaters on the whole have a bag-like sac, weakly muscular and diffusely glandular; those that live more on flesh

or on mixed diet have the muscular portion more specialized and a tendency to the concentration of the glands. Even a formation so remarkable as the aggregation of the proventricular glands into two large circular masses has apparently little or no systematic significance. Within the group generally, the arrangement of the proventricular glands is diffuse over the whole area, but there is a tendency for them to lie in longitudinal bands, which may be numerous, as for instance in the Sea-eagles and in *Baleniceps*, or in two bands one anterior and one posterior. I found these bands rather short and rounded off in the American Grebe (*Echmophorus major*) and even more definitely rounded off in Garden's Night-heron (*Nycticorax gardeni*). The condition I described and figured for the African Tantalus (*Pseudotantalus ibis*), where the glands are in a couple of rounded bosses, and which I noted as occurring also in *Leptoptilus crumeniferus* and *L. argala*, and in *Carphibis spinicollis* (25), is obviously a simple derivative from the pair of rounded bands. The state of affairs noted by Garrod in Levaillant's Darter (20) and by Forbes in the Indian Darter (11) differs from that in the Storks only by the circular form of the two patches being a little more advanced and by a slight tendency for the circular masses to retreat into eversion of the stomach wall, a condition which is completed in *Plotus ankinga* (19) by the two patches having retreated into a rounded diverticulum. It is clear that the absence of such circular patches in *Baleniceps* tells us nothing as to the place of that bird in the system.

When I found that there was a well-marked pyloric chamber, a fact which appears not to have been recorded before, I at once remembered the existence of such a chamber in the Pelican from my own notes, and in *Plotus* from the observations of Garrod and Forbes. But as Leuckart (loc. cit.), Gadow (14), Cazin (6) and many others have shown, a pyloric chamber in varying degrees of completeness of separation occurs in many birds, notably in Herons, Storks and Darters; and even if we try to follow Cazin in limiting the term to cases where the constriction from the larger chamber is very well-marked, its presence gives no sure ground for associating *Baleniceps* more closely with any one of the groups of allied birds.

*Liver*.—As Beddard (3) has noted, the right lobe of the liver is very much larger than the left, a condition which he was inclined to think showed affinity with the Herons rather than with the Storks. In a later work (4), however, he states that the "relative sizes of the liver lobes appear to be of no importance systematically"—an opinion with which I concur. There is a large gall-bladder, and the cystic and hepatic ducts open nearly together, but the cystic duct distad of the hepatic duct, just beyond the end of the straight distal limb of the duodenal loop of the intestines, the disposition being very like that figured by Beddard in the case of the Indian Darter (4, p. 32) except that the hepatic duct passes through the substance of the lobulated

pancreas. On referring to my own notes, I find that a closely similar arrangement occurs in a very large number of birds belonging to widely separated groups.

*Intestinal Tract.*—The most notable general feature of the alimentary canal is the extremely small bulk it occupied in the body compared with the size of the bird. The actual specimen stood nearly four feet high; when the alimentary tract and mesentery had been removed by cutting the duodenum close to the stomach and the rectum close to the cloaca, the little handful of viscera placed on the dissecting board was not so large as the similar mass from a duck. The calibre of the whole tract was narrow and fairly uniform, except that the cæcum and large intestine were rather wider. The aperture leading from the stomach (*i. e.*, from the pyloric chamber of the stomach) to the duodenum was excessively small (text-fig. 121, A, p. 653); a grain of millet would have had difficulty in passing through. The minuteness of this aperture is no doubt an adaptation similar in purpose to the hair-like brush found by Garrod in *Plotus anhinga* and the similarly placed plug found by the same anatomist in Levaillant's Darter (Garrod, 19 and 20), which he surmised to be devices for preventing the passage of fish-bones into the gut.

The minuteness of the exit from the stomach and still more the further guarding of the aperture by a plug of hair-like structures may have another advantage than prevention of the passage of fish-bones. The hair-plug occurs also in the Turkey-buzzard (*Cathartes aura*), which is certainly not a habitual fish-eater. In his "Last Journal" (12) under the date Aug. 20, Forbes mentions dissecting an example of *Plotus levaillanti* and finding the stomach full of nematodes, none of which, however, had penetrated beyond the plug, although several had been caught in it. I found a number of nematodes in the stomach of my specimen of *Balæniceps*. We know now that intestinal parasites may do much damage to the animals they infest, and it is possible that the plug of hairs in the Darters and the very small exit from the stomach in *Balæniceps*, serve the useful purpose of preventing nematodes, which have been eaten with the food, from entering the intestines, keeping them in the stomach where they may eventually be killed.

The aperture by which the distal end of the small intestine communicates with the cæcum and large intestine (text-fig. 123, B, p. 658) is only just a little larger than the opening into the duodenum. The structure of the alimentary tract shows that the Shoe-bill is adapted to make the most of a limited diet, consisting probably entirely of animal food, fish, frogs, or even small mammals; that the food must be retained for a considerable time in the stomach until it is very well macerated, for large lumps could neither enter the intestines from the stomach, nor even if they reached the intestines leave them by passing into the cæcum and large intestines. From much unpleasant experience in dissecting the alimentary tract of birds and mammals, I have learned to

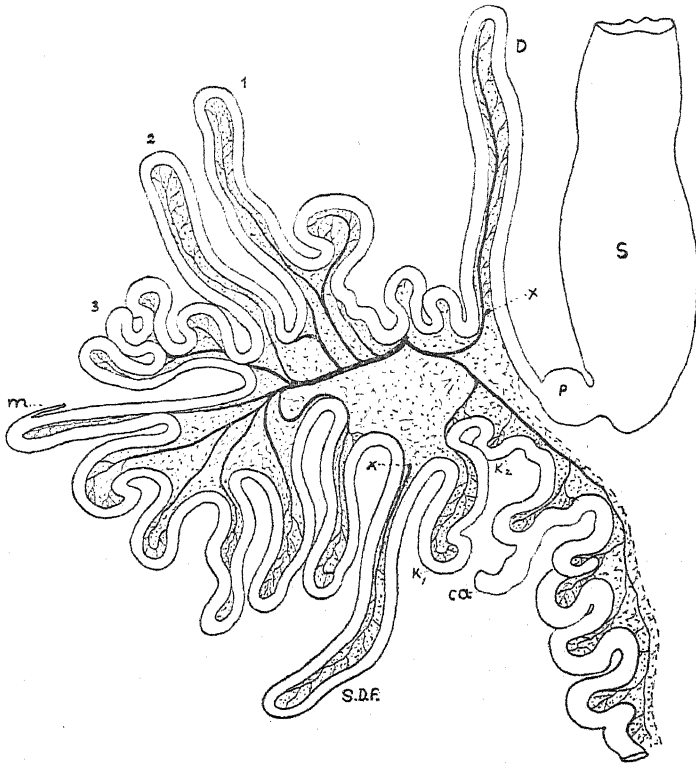
note differences in the odour on the dissecting table. In the case especially of vegetarian and omnivorous creatures where the digestive tract is bulky, and large quantities of food are taken, there is usually a very offensive odour, showing that putrefaction attends the processes of intestinal digestion. In other cases, and amongst birds, notably in birds-of-prey and many fish-eaters like the Divers, the odour of the alimentary tract behind the stomach is rarely offensive, and, sometimes, even attractive and aromatic. Although I was unable to examine this specimen of the Shoebill until it had been dead for several days, the contents of the intestinal tract were not offensive.

In the figure (text-fig. 122) I represent the course of the alimentary canal, from the stomach to the cloaca, dissected out in a fashion which, as I have described in former memoirs (26, 30), seems to me to give much information as to its morphology and to afford a useful basis of comparison with the conditions existing in the different groups of birds. The secondary foldings and modes in which the gut is packed in the body-cavity are naturally not shown by this method, but the relation of the gut to the primitive mesentery, the portions of it which have been expanded into loops, and the configuration of these loops, appear with diagrammatic clearness. The first specialized loop is the duodenum; it is relatively not quite so long as in Herons generally, but it shows on its distal limb a minor expansion, represented in the drawing as two short folds, and comparable with the condition which I have figured in *Nycticorax* and *Ardea*. Then follows a second definite loop with a minor loop on its proximal limb, then a well marked loop, and then a few irregular twists, after which comes the portion bearing the remnant of Meckel's diverticulum (text-fig. 122, *m.*), the vestige of the yolk-sac, lying in the line of axis of the main branch of the portal vein. In *Baleniceps* this was very slender, and bound closely to the inferior edge of the gut by a ventral mesentery. It might quite easily have been overlooked, if it had been sought for in the usual fashion, merely by running the gut through the fingers, but when the tract was laid out in the way I recommend, so that the blood-vessels were visible and the mesentery undisturbed, it was at once obvious. The part of Meckel's tract between this diverticulum and the usual position of the caeca is thrown first into a series of short ill-defined loops and then into a long and definite supra-duodenal loop (text-fig. 122, S.D.F.) closely attached to the duodenum in the undisturbed condition and supplied from the duodenal vein by what I have termed a "bridging" or short-circuiting vessel, which traverses the mesentery and must be cut through in process of laying out the gut (text-fig. 122 *x, x*). Then follows a rather irregular piece of gut forming two of the folds which I have described as "supra-caecal" kinks, the presence of at least one of these being characteristic of the great assemblage of birds containing the eagles and vultures, herons and storks, penguins and petrels.



Just behind the distal extremity of these kinks, the mesentery narrows so as to bring the distal end of Meckel's tract very close to the proximal end of the duodenum. This almost circular

Text-fig. 122.

Intestinal Tract of *Balaniceps*.

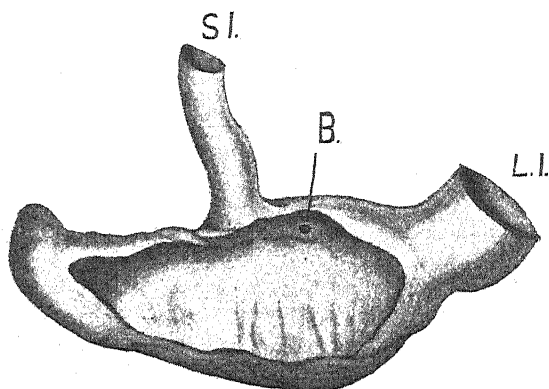
- S. Stomach.
- P. Pyloric chamber.
- D. Duodenal loop.
- 1, 2, 3. The three loops of Meckel's tract anterior to the diverticulum, typical of the Pelargo-Colymbomorphine Brigade.
- m. Meckel's Diverticulum.
- S.D.F. Supra-duodenal loop.
- x, x. Cut ends of bridging vessels from duodenal loop to supra-duodenal loop.
- K1, K2. Supra-caecal kinks.
- Ca. Caecum.

expanse of mesentery grows from the simple primitive loop of which the main branch of the portal vein is the axis and which

carries the yolk-sac at its extreme point. If, as happens in many birds belonging to widely separated groups, Meckel's tract is twisted in the course of growth, the twist in the mesentery is seen here with the result that in the dissection of the gut as shown in my figures, the mesentery carrying the posterior region of the gut may be tucked or folded under the mesentery carrying Meckel's tract, so that although the two are morphologically continuous, the continuity may not be apparent except where the whole gut is short or very simple. In my diagrams, I have simplified this region, showing the morphological continuity, as the secondary twisting was not a part of my argument.

The cæca (or cæcum) are to be looked for at this point, which marks the transition from Meckel's tract to the hind gut at the

Text-fig. 123.

Cæcum of *Baleniceps*.

S. I. Cut small intestine.

L. I. Cut large intestine.

B. The lateral wall of the cæcum has been cut away to show at B, the aperture into the small intestine, lying distally of the point where the intestine appears to pass into the cæcum.

beginning of the area drained by the posterior branch of the portal vein. In *Baleniceps* only one is present, as shown in the general diagram (text-fig. 122, Ca.). The end of Meckel's tract meets the large intestine almost at a right angle, and the cæcum is in continuation of the line of the large intestine. The calibre of the large intestine is rather greater than that of Meckel's tract, the difference being greater than is represented in the general diagram and rather less than in the enlarged figure (text-fig. 123), which was drawn from the specimen after it had been washed out and slightly stretched in the process of opening. The

aperture from the small intestine to the large intestine (text-fig. 123, B) is relatively extremely small and is considerably more posterior (nearer the cloaca) than the region where the one portion of the gut joins the other, the actual passage running in the conjoined walls for a certain distance. There is not more than the very slightest fold or bulge on the wall of the large intestine, which may be imagined rather than definitely stated to be a relic of an originally paired condition of the caeca.

The presence of a single caecum in *Baleniceps* has already been noted by Forbes (10) from a prepared specimen of that region of the gut mounted in the Museum of the Royal College of Surgeons, and this specimen corresponds in every particular with the example which I have dissected and figure in this communication to the Society. Beddard, however, (3) wrote as follows:—"In the intestines I could not discover any trace of caeca at all; I believe that the single caecum which characterizes the Ardeidae (there are two in the Ciconiae) may be extremely minute, and might therefore easily escape recognition in the spirit-preserved alimentary tract." I have probably examined carefully at least as many caeca of birds as any other anatomist, and Dr. Beddard's supposition seemed to me extremely improbable on general grounds. When I found that the specimen in the College of Surgeons' Museum was extremely like my own dissection, it seemed still more improbable that a structure so definite and peculiar could be present or absent in different individuals. Dr. Beddard examined viscera which had been preserved in spirit and which had been previously handled by some other investigator. On consulting with him, he was able to add to the information given in his memoir, that the late Professor Stewart was rather unwilling that so rare a specimen should be cut about too much, and he agreed with me that it was quite possible that the portion of the gut to which the caecum is attached had been removed before he examined it. Thanks to the kindness of Mr. R. H. Burne I have now had the opportunity of comparing the gut from the example I dissected with the actual material examined by Dr. Beddard in 1888. Dr. Beddard's material was in three pieces and the greater part of the mesentery had been cut away, but enough of the latter had been left to enable me to identify with complete certainty the general disposition of the gut, to recognize the duodenal loop followed by the subsidiary loops into which the hepatic ducts open, the large loop with its proximal minor loop, exactly as in the diagram from my specimen, the short loop with the remnant of Meckel's diverticulum (which Dr. Beddard, apparently, had not noticed) in precisely the same relative position on the loop and pointing forwards, the short twists preceding the supra-duodenal loop, and the latter loop. It was evident, moreover, that the remainder of the intestinal tract had been cut away, and that Dr. Beddard had failed to find the caecum because he had not quite the whole of the small intestine before him, and no part of the large intestine.

Examination of the preparation of the cæcum in the College of Surgeons' Museum, which Forbes had seen, as cited by Beddard in a footnote, made it most probable that that was the portion of the intestinal tract removed from the specimen Beddard examined. There is therefore no evidence in favour of Dr. Beddard's suggestion that the cæcum in *Baleniceps* may be absent, or so small as to be unnoticed.

The large intestine from the cæcum to the cloaca is relatively long in *Baleniceps* and is rather wider in calibre than the small intestine; it is thrown into a series of short irregular loops, threaded, so to say, on a mesentery which is much shorter than the course of the gut itself, and which in the usual way is drained by a large branch of mesenteric vein.

I have shown on a former occasion (30) that the characters of the intestinal tract are capable of affording a large amount of information as to the inter-relationships of the groups of birds. The primitive gut may be regarded as a tube not much longer than the length of the body-cavity it traverses and suspended from the dorsal body-wall by an antero-posterior mesentery. It is fixed at its anterior end, where it joins the stomach, at its posterior end, where it enters the cloaca, and near the middle of its length, on its ventral surface, where it is continuous with the yolk-sac. The great embryonic vein forms the chief radius of this crescentic loop, running up to the dorsal wall from the yolk-sac, and receiving a large tributary, which runs parallel with the dorsal wall, from the hind end of the body. In the course of growth the gut becomes much longer than the distance separating its anterior and posterior fixed parts, and the lengthening takes place by the outgrowth of subsidiary loops from the primitive gut. The position of these loops with regard to the fixed points of the gut, and their number and character, differ in different cases, with the result that when the alimentary tracts are laid out on the dissecting board in the fashion in which I have described, they form definite patterns. In their main features, these are constant in individuals of the same species, closely similar in the species of a genus, and show definite relationships in the families and greater groups. A type of pattern persists through the large divisions and shows a gradual increase in definiteness and specialization in the different members of these groups, with the result that the patterns can be arranged in family trees. These correspond so closely with information that can be derived from other anatomical characters, that I regard them as being an extremely useful guide to the relationships of birds. Obviously patterns are more easy to place in the system when they are highly specialized and complex, but even the shortened guts of fruit-eaters may retain marked indications of pattern.

In the great assemblage of birds which Gadow (16) has called the Pelargomorphine Legion, in which *Baleniceps* must certainly be placed, the pattern of the gut is relatively complex.

The duodenum is a definite loop, tending to be rather wide and further sub-divided in the Falconiformes, to be excessively long, twisted and rolled up with the first loop of Meckel's tract in the Ciconiiformes, to be very long, narrow and with a minor loop on its proximal limb in the Ardeiformes. In *Baleniceps*, it is not highly specialized, but the differentiation it displays is more like that in Herons than in Storks, especially in the formation of the secondary expansions at the base of its distal limb.

In the same assemblage Meckel's tract is long, and is suspended round the circumference of an almost circular expanse of mesentery which grows out from a very short portion of the primitive dorsal mesentery. It is roughly symmetrical about the main axis which runs out to the remnant of Meckel's diverticulum, the latter being invariably present. On the proximal half of the tract there is a tendency to the formation of three minor loops between the duodenum and Meckel's diverticulum. These tend to remain comparatively simple and similar in the Steganopods and in the Falconiformes. In the Ciconiiformes the tendency is for the first to become very long and secondarily twisted up with the duodenal loop, the second and third becoming nearly obliterated. In the Ardeiformes the first and second are generally rather long and definite and may form minor loops, the third is often reduced to a little bunch of small loops closely set together. In *Baleniceps* the three loops are rather more distinct than in either the Storks or the Herons, remaining in the more generalized Steganopod condition, but such differentiation as exists approaches the Ardeine pattern and shows no trace of the Ciconine peculiarities.

In the assemblage Meckel's diverticulum is actually or very nearly at the extremity of the axial loop of the tract. When it is not quite terminal, it is always on the proximal side of the loop and is then bent parallel with it, the free tip pointing proximally. The axial loop may grow out to a great relative length. These dispositions are distributed very irregularly throughout the whole assemblage which I am discussing. The axial loop, for instance, is long and has the diverticulum at the tip in some Storks and in many of the smaller Eagles and Falcons. It is short, but usually has the diverticulum at the tip in some of the Herons and in *Scopus*, *Cathartes* and *Polyborus*. It is short and bears the diverticulum proximal to its apex in *Phaethon*, *Pelecanus*, *Fregata*, *Pseudotantalus*, *Serpentarius* and *Neophron*. The latter condition exists in *Baleniceps*, and it is plain that its occurrence has no systematic significance.

In the Pelargomorphine Legion the distal part of Meckel's tract is less highly differentiated, and therefore affords fewer discriminating characters. The portion of it that follows Meckel's diverticulum is usually thrown into a bunch of short, irregular loops, and then follows a well-marked supra-duodenal loop, supplied from the mesenteric vein, and one or more definite supra-cæcal kinks. In *Baleniceps*, there is first the irregular region, then a definite short loop, then a long typical supra-

duodenal loop, and then two supra-caecal kinks. This region supplies no definite information which might help to place *Baleniceps* inside the Legion.

In the Legion the colic caeca are much reduced and apparently practically functionless except in the Anseriformes, in most of which they are very large and functional. Although reduced in the Steganopods, they are rather less so than in the Herons and Storks and occasionally contain faecal matter. I think the presence in *Baleniceps* of a single caecum, by no means so large as either of those in the Anseriformes, but definitely functional, communicating with the hind-gut and containing faecal matter, may be taken to be established. The presence of one caecum, instead of the normal pair, associates *Baleniceps* with the Herons. I should be disposed to guess that the loss of one caecum of the pair had taken place whilst both were functional, as there seems no particular reason why one of two vestigial organs should be suppressed, except as an occasional abnormality, and that the condition in the Herons, where there is a single functionless caecum, is secondary to that in *Baleniceps*.

The characters of the large intestine in Birds generally are not sufficiently differentiated to afford much information of systematic value. There seems to have been a general tendency to the reduction of this area to an extremely short and straight course from the caeca to the cloaca, a tendency which has been independently followed by the higher members of a large number of groups. *Baleniceps* has a relatively long and capacious large intestine, and in so far has remained in a rather more primitive condition than most of the members of the Pelargomorphine Legion.

To sum up, the characters of the intestinal tract of *Baleniceps* are those of the Pelargomorphine Legion, and such specialization as it displays associates it with Ardeine birds rather than with Ciconine birds.

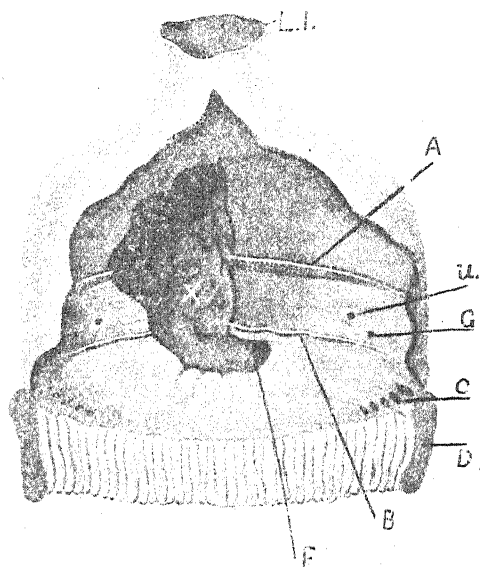
In a communication to this Society, Dr. Beddard (5) has made some additions to or corrections of my observations, particularly with regard to the presence of a specialized supra-duodenal loop in birds in which I did not record it, which are the more valuable as my work stretched over a number of years, as material was available, and it was only in its course that I began to recognize the significance of the various points and what had specially to be looked for. Dr. Beddard also on several grounds throws doubt on the value of my mode of displaying and comparing the intestinal tract patterns. These grounds are due to misapprehension. He thinks that my method of figuring the tract gives "an appearance of simplicity that is misleading, with the result that birds which are separated by marked characters are represented as being almost identical." Certainly the patterns (even if correct) do not in every case afford enough information to place clearly, or to separate clearly cases where the patterns are very simple. I was rather careful to insist on this point in

my memoir. He also thinks that I do not distinguish sufficiently between what he terms "fixed loops definitely formed by a narrow mesentery, and the irregular folds into which any mobile coil of the intestine may fall when disposed on the dissecting board." The whole tract is of course supported by mesentery, and Dr. Beddard's "fixed loops" and irregular folds are merely the beginning and final result of differentiation. The loops to which I have called attention are fixed by their morphological position, and they may be wide or narrow, long or short. More serious, however, is Dr. Beddard's misapprehension of the morphology of the gut which leads him into very curious comparisons. He states "that there are no essential differences between the intestinal tract in Birds and Crocodiles." He accepts as "perfectly correct" a diagram I gave (26, p. 137) of the alimentary tract in the Alligator, in which the canal is displayed as showing a series of almost exactly similar loops from the stomach to the cloaca, suspended on a crescentic fold of mesentery. As the pancreas lies in the first of these loops, the latter may by analogy be called the duodenum, but it is simply the first of a set of regular loops. Meckel's tract and the delimitation between that and the large intestine are not shown; it is quite clear that Meckel's tract is not differentiated. Comparison with the next figure, that of the tract in an embryonic pheasant, shows the essential difference. Immediately posterior to the duodenum a mesenteric area, corresponding to a very short length of the whole distance from the stomach to the cloaca, grows out into an enormous nearly circular tract, of which the great vein from the yolk-sac forms nearly a diameter. This region is Meckel's tract, and from the point where it returns to the dorsal line again and where the cæca, if present, are given off, the large intestine begins, and corresponds to a much larger part of the primitive distance from the pyloric extremity of the stomach to the cloaca, than the combined length of origin of the duodenum and Meckel's tract. This mode of development of the gut dominates its adult morphology. So also Dr. Beddard does not appreciate the morphological importance of the position of Meckel's diverticulum, the remnant of the yolk-sac. Fortunately it persists throughout life in most of the different groups, and its presence rules out such comparisons as Dr. Beddard makes between particular loops in *Rhea* and a *Tinamu* (with a *Passerine* intervening in the argument!). He is trying to identify different morphological material, belonging to different somites of the embryo, and this error makes his conclusions invalid. It would be of great interest to examine young chicks of those birds in which the rudiment of the yolk-sac does not usually persist, and this would clear up some of my dubious cases. But so far as they go, the gut-patterns afford an amazingly conclusive body of evidence as to the Avian system.

**CLOACA.**—The rectal portion of the large intestine expands suddenly to enter the large cloaca. The first chamber of the cloaca, called the coprodæum by Gadow, is separated by a thin

transverse fold (text-fig. 124, A) from the second, much narrower urodaeum. The paired ureters open into the latter (text-fig. 124, U) on the dorsal surface but rather laterally placed. The actual apertures are situated on a small ridge and were very difficult to see, considering the size of the bird. I found them eventually by passing a horse-hair backwards through the ureter, and I think

Text-fig. 124.

Cloaca of *Baleniceps*. Ventral view.

The sphincter has been cut through in the middle ventral line and folded outwards; portions of the dorsal wall of the gut have been removed.

- L.I. Cut end of large intestine.
- A. Fold separating Coprodaeum from Urodaeum.
- B. Fold separating Urodaeum from Proctodaeum.
- U. Aperture of Ureter.
- G. Genital aperture.
- C. Glandular crypts.
- D. Cut sphincter muscle.
- F. Aperture of Bursa Fabricii; x, Dorsal wall of Bursa.

it possible, although I am not certain, that there were several very small apertures at each side instead of one large one. Rather lateral and slightly posterior to the ureters were the minute openings of the vasa deferentia (text-fig. 124, C). There was no genital papilla, but the specimen was a very immature male, and the testes were minute. The vas deferens accompanied



the ureter until the latter nearly had reached the wall of the cloaca, and then twisted outwards. A transverse fold also separated the urodæum from the proctodæum (text-fig. 124, B). In the proctodæum, at each side and just at the edge of the splincter, were four or five little glandular apertures leading into small cavities lined with irregular ridges. I find in my notes of dissections of Ostriches, both male and female, that similar glandular crypts are present in that bird. In the middle line of the proctodæum, just behind the fold separating that chamber from the urodæum, lies the large, elongately oval aperture of the Bursa Fabricii (text-fig. 124, F). The bursa is a very large chamber, lying above the cloaca, running forwards almost to the rectum. The inner wall is lined by irregular, heavy ridges, making it resemble the reticulum of a ruminant stomach. In the figure, part of the dorsal wall of the coprodæum and urodæum is represented as cut away to show the cavity. The bursa was empty. There was no trace of a penis.

Our knowledge of the Bursa Fabricii is due chiefly to Forbes, later writers having added very little to his observations and conclusions (9). In Struthious birds, especially when they are young, there is practically no constriction separating the proctodæum and the bursa, the latter being simply a forwardly directed and dorsally placed continuation of the cavity of the posterior division of the cloaca. In the different groups of birds there appears to be a general tendency for a convergent modification of this simple arrangement; the constriction between proctodæum and cloaca becomes more and more pronounced, until the bursa becomes a tubular or pyriform sac opening by a very small pore into the dorsal wall of the cloaca. This progressive change is most marked in Passerines and in those birds in other groups which most nearly mimic the passerine type, and may lead to the complete disappearance of the aperture and of the bursa. There is of course no reasonable doubt but that the Passerines present the most specialized results of avian evolution. To a certain extent, ontogenetic changes in the bursa show a similar course of change, the aperture of the bursa narrowing, and the bursa itself tending to contract and even to disappear with age. There is probably, therefore, no special significance in the condition of the bursa in the example of *Baleniceps* I dissected, its large size and wide aperture being perhaps due to youth. Forbes, however, states that in the Storks and Herons he examined, the bursa was large and its aperture small. He also mentions the absence in these birds of the reticulum of ridges in the lining wall of the bursa, although he found them in Steganopods much as I describe them in *Baleniceps*. I cannot draw any systematic conclusions from these facts.

A small penis is stated to be present in Storks, absent in Herons, so that in the absence of that organ *Baleniceps* resembles the latter group, but I attach no systematic value to this.

## MUSCULAR ANATOMY.

## MUSCLES OF HEAD.

*Dermo-temporalis*.—This thin but extensive sheet of muscle arose at each side by a fleshy, narrow head, behind and above the temporal fossa and close to the origin of the biventer maxillæ, and spread out on the skin of the ventral surface and sides of the neck, precisely as in the Pelican.

*Biventer maxillæ* was very large and strong, arising from a well-marked area on the back of the head behind the quadrate and inserted to the posterior end of the lower jaw. As in the Pelican, I could not separate this from the underlying digastric or depressor mandibulæ.

*Temporal*.—External portion. A very strong mass, arising from the dorsal part of the temporal fossa back to the biventer, runs downwards and forwards, dipping under the ramus of the maxilla to be inserted to the outer and upper surface of the lower jaw opposite the orbit.

Pyramidal portion. Strong fan-shaped muscle arising transversely under the post-orbital process and converging to a rounded tendon which runs forwards and outwards to the inner side of the lower jaw. Parallel with this, and possibly a separate portion of it, is a flat band of muscle running from close to the articulation of the quadrate, alongside the tendon of the pyramidal portion to be inserted just anterior to it.

Quadrato-mandibular portion. Very strong fleshy muscle running transversely from the whole of the anterior surface and forward process of the quadrate to the ramus.

Quadrato-orbital portion. Long muscle from just behind the optic foramen across to the whole inner edge of the orbital process of the quadrate.

*Pterygoid*.—An enormous mass of muscle, partly separable into layers, on the lower surface of the jaw, from the posterior angle and ventral posterior portion of the mandible running forwards to the pterygoids.

The temporal and pterygoid muscles are practically identical with what I have found in the Pelican.

*Biventer cervicis*.—I examined this muscle to see if there were any trace of the peculiar formation described by Garrod in the case of the Darters, but found that the muscle with its anterior and posterior bellies was quite normal.

## HYOID MUSCLES.

*Mylohyoid anterior*.—As in the Pelican a very slender and thin sheet of muscular fibres superficial to the other muscles of the under surface of the jaws, and running transversely across from the ramus of the jaw to spread out on the interspace between the two rami, but without meeting its fellow in a median raphæ.

*Mylohyoid posterior*.—Arises as a broad strap from the outer surface of the angle of the jaw just below the ear and divides into

a thin wide sheet of fibres which runs over the ventral surface, meeting its fellow of the other side and forming a platysma myoides, and a better defined band which runs across to be inserted to the ceratohyal, superficial to both divisions of the geniohyoid.

*Geniohyoid*.—Two well-marked divisions. A very strong division arises from the last joint and cartilaginous end of the ceratohyal, round which it is wrapped, and runs forwards to the outer surface of the lower jaw just under the orbit. The second division arises from the first joint of the ceratohyal and runs straight forwards as a sheet of fibres which meets the corresponding fibres of the same division of the other side. These fibres can be traced up to the junction of the rami of the mandible.

*Genioglossus*.—Probably in relation with the degeneracy of the tongue, this muscle was absent.

*Ceratoglossus*.—Fleshy from the outer side of the first joint of the ceratohyal to the tip of the tongue. There was no separate tendon.

The hyoid muscles, like those of the head, of *Baleniceps* were excessively like those of the Pelican, but I attach no systematic importance to the similarity, as I have very little material with which to compare these muscles in a number of different groups, and the material I have shows that, apart from obviously adaptive features, these muscles are much alike in widely separated groups.

#### CAUDAL MUSCLES.

*Pubo-coccygeus externus*.—A flat band of muscle from the posterior dorsal margin of the end of the pubis, narrowing to its insertion on the under surface of the sheath of the external rectrix.

*Pubo-coccygeus internus*.—This is a much wider and thinner muscle, deep of the externus, and arising from a greater area of the pubis with a reach on to the ischium. It is inserted to the hæmapophyses of the posterior caudal vertebræ.

*Levator coccygis*.—The two levators form a strong diagonal mass of musculature on the dorsal surface of the tail, anterior to the oil-gland. They arise from the ilium and the lateral processes of the caudal vertebræ and are inserted by a series of tendinous slips to the spinous processes of the caudals and to the membrane covering the rectrices.

*Depressor coccygis*.—Arises from the transverse process of the last sacral vertebra by a strong tendon just at the articulation with the ilium, and from the transverse processes of the first three free caudals; insertion to the transverse processes and hæmapophyses of the posterior caudals.

*Ilio-coccygeus*.—Only the outer of the two slips which usually represent this muscle is present. It arises from the ilium just dorsal to the origin of the depressor coccygis, and is inserted to the outer surface of the capsule of the external rectrix.

I have no standard for comparison in the case of the caudal muscles. The chief difference from the condition in *Leptoptilus* is the absence of the inner slip of the ilio-coccygeus.

#### MUSCLES OF THE SHOULDER AND WING.

*Cucullaris*.—The cervical portion is well developed, forming a definite sheet of circular fibres which stop abruptly in line with the proximal edge of the rhomboideus externus where they are inserted along the clavicle.

*Rhomboideus externus*.—Origin tendinous from the neural crests of five and a half vertebræ beginning at just opposite the junction of the scapula and clavicle. The fibres run outwards nearly transversely to all the scapula except the down-turned posterior end and forwards to part of the clavicle (text-fig. 125, Rh. 2).

*Rhomboideus profundus* or *internus*.—Origin tendinous, a little short of the externus proximally and reaching just beyond it distally. The fibres run outwards and backwards to no part of the clavicle but to the whole length of the scapula including the down-turned end (text-fig. 125, Rh. 1).

The two rhomboid muscles are nearly equal in thickness. These two muscles, according to Fürbringer, and my own observations confirm his view, are in process of creeping forwards. Their condition in *Balaniceps* shows a considerable degree of specialization, but I have not material to compare the condition in allied birds.

*Latissimus dorsi anterior*.—A broad strap of muscle arising from the anterior dorsal vertebræ only and running downwards and forwards, dipping under the anconeus, to a fleshy insertion to the shaft of the humerus distal of the insertion of the posterior division of the muscle and unconnected with it (text-fig. 125, L.A.).

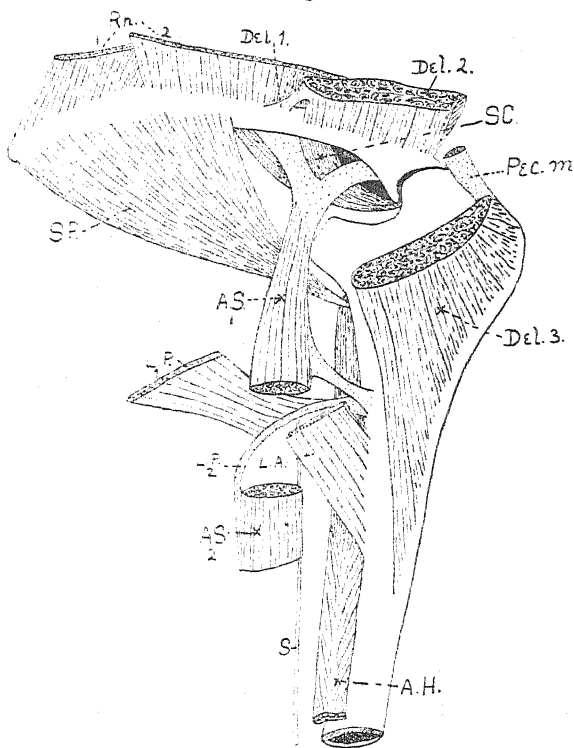
*Latissimus dorsi posterior*.—Fleshy origin, the anterior edge of which touches but is not fused with the posterior edge of the anterior division. Origin wider than that of the anterior division, but not reaching quite as far back as the proximal edge of the ilium. Its fibres converge to form a band about the same width as the lat. dorsi anterior (text-fig. 125, L.P. 1), pass under that muscle with a more proximal slope, to be inserted along a strong tendon (text-fig. 125, L.P. 2) which is inserted to the scapula under the scapular anchor of the anconeus, proximal to the insertion of the lat. dorsi anterior, and which joins the anconeus belly distally.

*Latissimus dorsi metapagialis*.—Absent.

The anterior division is like that in *Leptoptilus*. The connection of the tendon of insertion of the posterior division with the anconeus occurs also in *Leptoptilus*, but I have noted a somewhat similar arrangement in *Bubo maximus*. The loss of the metapagial division has been noted by Fürbringer in *Plotus*, but it is usually present in the Herons, Storks, and Steganopods.

*Serratus superficialis anterior*.—From the ventral end of the last cervical rib and the first dorsal rib converging to a flat

Text-fig. 125.

Shoulder-muscles of *Baleniceps*.

Right wing, external aspect. Muscle striped: tendon dotted.

- Rh. 1. Rhomboideus profundus, cut across.
- Rh. 2. Rhomboideus externus, cut across.
- Del. 1. Tendinous anchor of Deltoides major.
- Del. 2. Cut surface of Deltoides major reflected.
- Del. 3. Distal portion and insertion to humerus of Deltoides major.
- S.P. Scapulo-humeralis posterior.
- Pec.m. Tendon of insertion of Supra-coracoideus (Pectoralis minor or secundus).
- SC. External scapular head of Sub-coraco-scapularis.
- A.S.<sub>1</sub>. Anconeus scapularis, showing scapular origin, and anchor to humerus. It has been divided to show the Latissimus dorsi.
- A.S.<sub>2</sub>. Anconeus scapularis, part of the belly.
- A.H. Anconeus humeralis.
- L.A. Latissimus dorsi anterior, insertion.
- L.P. 1. Cut edge of Latissimus dorsi posterior.
- L.P. 2. Tendon of insertion of Lat. dorsi posterior from humerus to junction with Anconeus scapularis.
- S. Vestige of Expansor secundarius. The distinctness of this is exaggerated in the drawing.

tendon which is inserted to the postglenoid scapula between the two parts of the sub-coraco-scapularis, its insertion being quite covered by the outer part of that.

*Serratus superficialis posterior*.—From the first two uncinate processes and area of their ribs in line with them to about three-quarters of an inch of the posterior inferior border of the scapula; covered by the third portion of the serratus superficialis.

*Serratus superficialis metapatagialis*.—Origin from the same two ribs as the ser. super. posterior, but entirely from below the uncinate processes, and reaching down almost to the sternum. Insertion to the metapatagium, with a strong tendinous slip to the tip of the scapula.

The first of the three serrati, according to Fürbringer, is very variable even within families. The second is constant in many families, variable in others. The limitation of the origin to dorsal of the uncinates is somewhat rare but has been noted in *Phenicopterus*. The insertion of the serratus metapat. partly to the scapula appears to be extremely rare. Fürbringer has noted it in *Crex*, where the condition is much as I find it to be in *Balaniceps*, and in *Fulmarus* and *Bucorvus*, where the scapular insertion alone occurs. The relation to the scapula is probably a vestige of the origin of this muscle as a separated portion of the serratus superfic. posterior.

*Serratus profundus*.—From the last two cervical and first two dorsal ribs to the scapula in four digitations. According to Fürbringer, this arrangement is normal in Herodii.

*Biceps brachii*.—This arises by a flat narrow tendon from the acrocoracoid (text-fig. 128, B. 1, p. 675), alongside but not covered by the origin of the coracobrachialis externus and separated by that muscle from the tendon of insertion of the supracoracoideus (pectoralis secundus). It passes under the insertions of the pectoralis major without being connected with them, and passing into a rounded belly (text-fig. 128, B. 2) runs down parallel with the humerus to be inserted to a knob on the ulnar face of the radius (text-fig. 127, Bi., 1, p. 672). It is then continued across to the opposite face of the ulna (text-fig. 127, 4, 5) by a deep broad tendon and a narrow more superficial tendon, first sending a strong slip (text-fig. 127, 2) to the radial end of a radio-ulnar ligament.

The biceps obviously presents a highly specialized condition in *Balaniceps*, the specialization consisting of the complete loss of the usual humeral head. The two divisions are well separated at their origin, and the radial and ulnar tendons of insertion separate rather high up in most Steganopods, Storks and Herons. As Fürbringer has pointed out, the humeral head in such cases can be traced to the radial insertion. As both radial and ulnar insertions are well marked, indeed rather unusually complex in *Balaniceps*, I infer that the loss of the humeral head is comparatively recent.

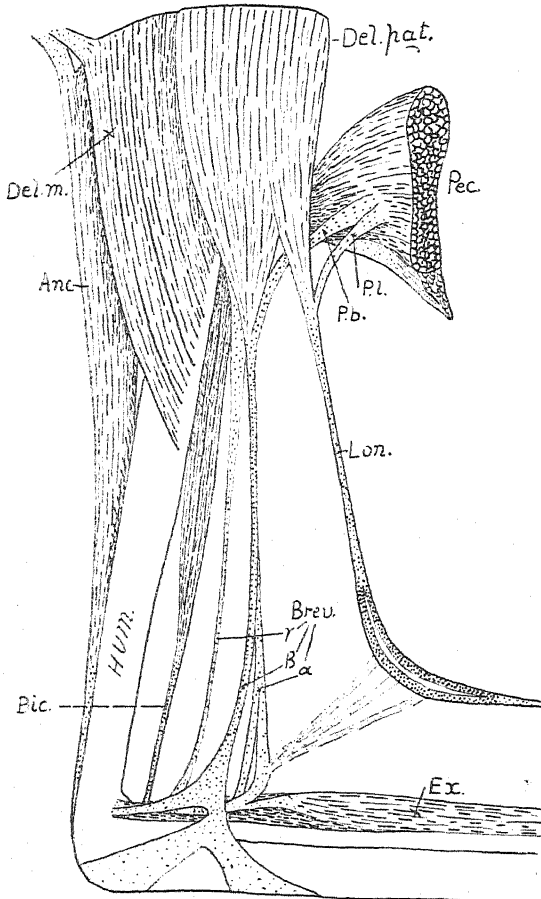
*Biceps patagialis*.—This slip to the patagial tendons is absent

in *Balcaniceps*, as in Storks, Herons, *Scopus*, and most Steganopods. The absence, however, is not of much value; the slip is present in some Steganopods, in Spoonbills, in *Phenicopterus*, and is present or absent within the same family in a number of cases.

*Deltoides propatagialis* (text-fig. 126, Del. pat.).

I have already mentioned that there is no biceps propatagialis.

Text-fig. 126.



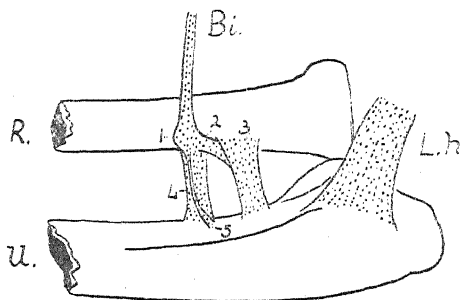
Patagial muscles and tendons of *Balcaniceps*.

Del.m. Deltoides major. Anc. Anconeus scapularis. Hum. Humerus. Bic. Biceps. Del.pat. Deltoides propatagialis. Pec. Pectoralis major cut across. Pl. Pectoralis slip to longus tendon. P.b. Pectoralis slip to brevis tendon. Lon. Longus tendon. Brev. Brevis tendon with the slips named  $\alpha$ ,  $\beta$ , and  $\gamma$  by Fürbringer. Ex. Extensor metacarpi radialis.

There is no cucullaris propatagialis. The patagial tendons arise solely from the deltoides propatagialis and from the pectoralis propatagialis, and there are no anchors to the humerus.

The origin of the deltoides patagialis is from the clavicle, acrocoracoid ligament and part of the scapula, the latter origin not being found in Herons. Distally it splits into two peaks, a smaller from which the longus tendon arises and a larger for the brevis tendon. This is a more specialized condition than in Steganopods, Storks and Herons generally, where even the longus and brevis tendons have a short common course, but in *Scopus* and *Leptoptilus* there are separate peaks for the tendons.

Text-fig. 127.



Insertion of Biceps ligament.

R. Radius. U. Ulna. Bi. Biceps tendon: 1, insertion to radius; 2, insertion to radio-ulnar ligament; 4, insertion to ulna; 5, second superficial insertion to ulna; 3, radio-ulnar ligament. L.h. Humero-ulnar ligament.

The longus tendon (text-fig. 126, Lon.), after being reinforced by a slip from the pectoral, enlarges in width and becomes elastic, this portion being doubled, and being anchored by a very faint (much fainter and more diffuse than would appear from the drawing in fig. 126) set of fibres from the distal portion of the brevis.

The brevis tendon (text-fig. 126, Brev.) is highly specialized. The main mass of the muscle passes into a strong rounded tendon which is reinforced by the pectoralis slip and represents the conjoined  $\alpha$  and  $\beta$  slips of Fürbringer, the beta slip being the direct continuation of the muscle, but giving off half-way down the patagium a broader and weaker alpha slip. The latter itself becomes doubled distally, gives off a weak anchor to the elastic portion of the longus tendon and is inserted to the extensor metacarpi radialis tendon. The beta slip broadens out as it reaches the fascia over the extensor, sends forward a stout anchor which covers and is fused with the tendinous head of the extensor metacarpi, and sends downwards a branch which forms a forked fan reaching the distal edge of the forearm. The gamma slip of



Fürbringer is the most proximally placed, and is distinct although very flat and weak throughout its whole length from its origin at the proximal side of the brevis muscular peak to its insertion to the recurrent beta slip.

The course of evolution of the brevis tendon appears to have been from a wide rather diffused band to first a specialization of portions of that band into the slips distinguished by Fürbringer, then to a separation of these slips, and finally to the loss of one or more of them. In the Storks, Herons and *Scopus* the slips are at least separate distally; in Storks and Herons the separation of alpha and beta is only distal and does not begin so high up as in *Baleniceps*, in which, although the actual separation occurs only about half-way down the patagium, the identity of beta can be traced right up to its origin. Beddard figures an almost similar condition for *Scopus* (2, fig. 2). So also the very complete separation of gamma and beta occurs in *Scopus* and *Baleniceps*, and is much less distinct except distally in Storks and Herons. The resemblance between *Baleniceps* and *Scopus* appears to be rather close; the most important differences being the greater distinctness of the anchor to the longus in *Scopus*, and the presence of an anchor to the humerus in the same bird.

*Deltoides major* (text-fig. 125, Del. 1, Del. 2, Del. 3, p. 669; text-fig. 126, Del.m.; text-fig. 128, De.).—This large muscle arises fleshy from the scapula but with a distal tendinous anchor just external to that of the anconeus, and is inserted fleshy to nearly half-way down the humerus. It is very nearly divided into the two portions visible in *Leptoptilus* and other storks. The tendinous anchor occurs in the Herons and Storks that I have dissected, and Beddard has recorded it in *Scopus*.

*Deltoides minor*.—This muscle, possibly owing to the large size of the *deltoides major*, is not to be distinguished as a separate muscle: probably it is absent. In Storks it is small and quite separate.

*Scapulo-humeralis anterior*.—This small muscle is absent. In Steganopods, Storks and Herons it lies very close to the *teres major*, so that it is possible that it may have fused with this in *Baleniceps*. Beddard does not mention it in his description of the shoulder muscles of *Scopus*, so that possibly it may also be absent in that bird.

*Scapulo-humeralis posterior* (*Teres major*) (text-fig. 125, SP).—A strong but relatively rather small muscle arising from about the distal half of the scapula and inserted to the humerus between the two heads of the anconeus. A relatively narrow insertion, according to Fürbringer, also occurs in Steganopods, Storks and Herons. In *Baleniceps* it has no accessory anchors or attachments.

*Sub-coraco-scapularis*.—The coracoid head (*Coracobrachialis brevis* of Garrod) is single and much smaller than the scapular heads. It arises only from the proximal half to third of the inner face of the coracoid, as in Storks and Herons, and converges

to join the scapular heads near their tendon of insertion. The external (text-fig. 125, S.C., p. 669) and internal scapular heads arise from about the second fifth of the under surface of the scapula, where they are separated by the insertion of the serratus superficialis anterior. The three heads unite to form a strong rounded tendon inserted to the median tubercle of the humerus.

#### *Anconæus.*

*Anconæus scapularis*.—Origin by a strong forked tendon from scapula (text-fig. 125, A.S. 1, A.S. 2), passes into a rounded muscular belly which sends an anchor to the humerus near the insertion of the latissimus dorsi and receives a strong tendon from the latissimus dorsi posterior. Passes into a strong flat tendon just before reaching the elbow.

*Anconæus humeralis* (text-fig. 125, A.H.).—Origin from the whole length of the humerus, the origin being cleft proximally. Passes into a tendon at the distal end of the humerus, and this runs parallel with but united only by membrane to the tendon of insertion of the *anconæus scapularis*. Insertion to the olecranon of the ulna.

The forked head of the scapular portion, the anchor to the humerus, and the general relations of the two divisions of the muscle are very much like what I have observed or find recorded in Storks and Herons. The absence of any extension of the scapular head to the clavicle or coracoid is rather a primitive feature.

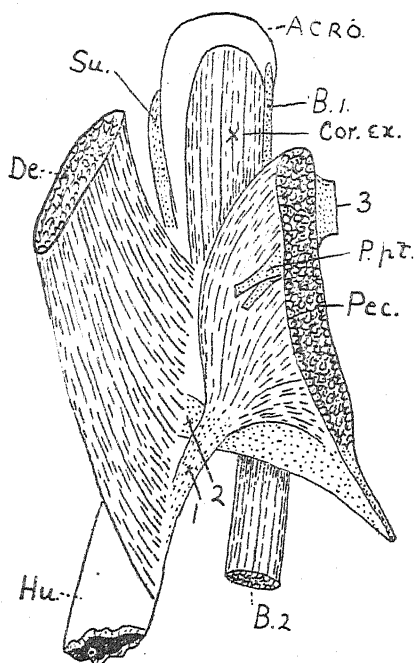
*Anconæus caput coracoideum* (*Expansor secundariorum*) (text-fig. 125, S.).—At the elbow there was a slip of muscular fibres connected with the feathers and giving rise to a very delicate tendon which I traced up the under surface of the skin close to the *anconæus*, but which then appeared to become diffuse and be lost in the subdermal fasciæ. There was no trace of it passing through the edge of the *teres major*, as usually happens when it is well developed, or in the axilla.

This was one of the muscles to which Garrod paid great attention, hoping to find it useful in classification, but further observations have not justified his anticipations, as it is present or absent in very closely allied birds. It is usually absent in Steganopods, but present in a few cases. It is present in Storks, and in Herons except *Ardeetta* and *Canceroma*. According to Beddard it is absent in *Scopus*. Its vestigial presence in *Baleniceps* is therefore interesting but of no systematic value.

*Pectoralis thoracicus*.—The great pectoral (text-fig. 126, Pec., p. 671; text-fig. 128, Pec.) in *Baleniceps* is an enormous mass of muscle arising from the clavicle, the membrane between the clavicle and coracoid, from the whole of the keel and from all the posterior part of the sternum with a considerable overlap to the ribs. I could not trace any definite horizontal division of the muscular mass. The insertion is by two very distinct tendons, which cross each other in a remarkable fashion. The greater and more

proximal mass of the muscle converges to a strong flattened tendon (text-fig. 128, 1), which is inserted to the humerus rather distally and not far from the posterior end of the deltoid insertion. The more distal portion of the muscle converges to a much broader tendon, which forms the posterior border of the whole muscle and then dipping under the first tendon of insertion runs in to the humerus proximally of it (text-fig. 128, 2). There is also a strong anchor to the humerus, shown as cut and reflected in the figure (text-fig. 128, 3).

Text-fig. 128.

Pectoral muscle of *Baleniceps*. Tendon dotted; muscle striped.

Acro. Acrocoracoid process. Hu. Humerus.

Pec. Pectoralis major, cut across.

1, 2. Insertion tendons of pectoralis to humerus. 3. Anchor to humerus, divided and reflected.

P.pt. Pectorales propatagiales.

Su. Tendon of insertion of supratoracoides (Pect. minor).

De. Deltoides major.

Cor. ex. Coracobrachialis externus.

B.1. Tendon of origin of biceps. B.2. Cut belly of biceps.

The large area of origin of the great pectoral is of course associated with a powerful wing, and is probably purely adaptive

The strong proximal anchor (text-fig. 128, 3) to the humerus also occurs in many Steganopods, in Storks, Herons, and is probably represented in *Scopus*, in which bird Beddard mentions a strong insertion to a fibrous aponeurosis attached to the crista of the humerus and covering the biceps. It is characteristic of Storks as opposed to Herons, that in the former birds the great pectoral is completely divided into two muscles, as it is in the Pelican and some other Steganopods. The insertions of these portions as described by Weldon correspond almost exactly with the double insertion in *Baleniceps*, and I was able to separate the mass of muscle quite easily into portions corresponding with these insertions, although, in the absence of the separate insertions, I should not have described the muscle as doubled. But, whatever the distinction be worth, the great pectoral muscle of *Baleniceps* is more Ciconine than Ardeine. Beddard's description of the condition in *Scopus* is not sufficiently detailed to follow in this matter, but he speaks of it as "partly doubled," and the humerus shows marks of a double insertion.

*Pectoralis propatagialis* (text-figs. 126, 128, pp. 671, 675).—As I have already stated, there are separate slips from the pectoral for the longus and brevis tendons. Both slips are entirely tendinous, and that for the longus is smaller and more superficial (text-fig. 126, P.l., P.b.; text-fig. 128, P.pt.). In my dissections of Herons, I find similarly distinct slips for the brevis and longus from the pectoral; Beddard mentions them for *Scopus*, but in the case of Storks the usual arrangement appears to be the more primitive condition of a single slip, which joins the patagial tendon before that has divided into longus and brevis.

*Pectoralis abdominalis*.—This is absent in *Baleniceps* as in Storks. It is present in Herons, but Beddard does not refer to its presence or absence in the case of *Scopus*.

*Supracoracoideus* (*Pectoralis minor*).—This is a small and rather narrow muscle elongately oval, with a centrally placed tendon like the mid-rib of a leaf. Its fleshy origin is limited to a very small part of the sternum, including no part of the keel, and part of the coracoid and the membrane between the coracoid and clavicle. It is widely separated on the coracoid from the origin of the *coracobrachialis posterior* (*pectoralis tertius*) and its tendon of insertion (text-fig. 128, Su.) is free from any fibres that could represent a *deltoides minor*. Its general relations and small size are closely paralled in Herons and Storks.

*Coracobrachialis externus* or *anterior*.—A strong muscle arising fleshy from the acrocoracoid only (text-fig. 128, Cor. ex.) and covered only at the extreme edge by the tendon of origin of the biceps. Insertion on a broadly oval area to the planum bicipitale of the humerus.

*Coracobrachialis internus* (*Pectoralis tertius*).—A very stout almost doubled mass of muscle from the distal dorsal two-thirds of the edge of the coracoid opposite the origin of the supracora-

coideus, but quite separate from that. Its fibres converge to a strong tendon inserted to a peak of the median tubercle of the humerus.

#### MUSCLES OF FOREARM AND NECK.

*Brachialis inferior*.—A very strong flat sheet of muscle with a fleshy origin and insertion, occupying the angle between the humerus and ulna, the insertion to the ulna being twice the width of the origin from the flexor aspect of the humerus.

*Pronator sublimis* or *brevis*.—Short muscle from the inner condyle of the humerus to the first quarter of the radius. This insertion is rather shorter than in *Leptoptilus*.

*Pronator profundus* or *longus*.—As in *Leptoptilus* a larger muscle, from the inner condyle of the humerus to a little beyond the surface of the radius covered by the *brevis* and more on the ulnar aspect than the *brevis*.

*Entepicondylulo-ulnaris*.—Absent, as in *Leptoptilus*, but according to Gadow present only in *Rasores* and *Tinamus*.

*Ectepicondylulo-ulnaris*.—From outer condyle of the humerus to first third of ulna on its radial face. A very thick and strong muscle, closely united with the flexor digitorum profundus. As in *Leptoptilus*.

*Ectepicondylulo-radialis*.—A thin muscle arising by a flat tendon from the outer condyle of the humerus along with the extensor digitorum communis, inserted to a quarter of the radius; as in *Leptoptilus*, except that the insertion is shorter in the latter bird.

*Flexor carpi ulnaris*.—From the inner condyle of the humerus with a sesamoid; runs down the inner surface of the ulna to the great tuberosity of the ulnar carpal. Arising as a fleshy belly a thinner tendon connected with the quills runs down to end on the carpal alongside the great tendon. As in *Leptoptilus*.

*Ulni-metacarpalis ventralis*.—Fleshy from the last third of the ulna on the radial face; tendon crosses over a slide on the radial carpal and is inserted on a hump of the second metacarpal near the attachment of the pollex.

*Ulni-metacarpalis dorsalis*.—Short muscle arising by a tendon from the distal end of the ulna on its lateral face; it divides into a shorter portion running straight across to the upper part of metacarpal III and a broader portion inserted to about two-thirds of the upper surface of metacarpal III, where that is free. Similar in *Leptoptilus*, except that the first portion is tendinous, the second fleshy, while both are fleshy in *Baleniceps*.

*Extensor metacarpi radialis*.—Two heads, outer tendinous, inner fleshy, from the outer condyle of the humerus. The outer belly is quite separate from the inner belly and is connected with the *brevis* tendons of the patagium (text-fig. 126, Ex., p. 671). Insertion to the base of metacarpal I, the tendons from the two

bellies remaining separate until their insertion, so that the muscle is completely double. In *Leptoptilus* the tendons fuse distally.

*Extensor metacarpi ulnaris*.—Arises from the external condyle of the humerus by a tendon superficial to that of the ectepicondyloulnaris; then a long fleshy belly, then a thin tendon passing over a groove in the distal end of the ulna from which it receives a strong anchoring slip, absent in *Leptoptilus*, to its insertion on metacarpal II just where metacarpal III is given off.

*Flexor digitorum sublimis*.—A strong band of tendon runs from the inner condyle of the humerus to the ulnar carpal, from the upper side of which the flexor digitorum sublimis arises as a delicate fleshy muscle giving rise to a slender tendon which passes over a groove in the ulnar carpal and is inserted to the base of phalanx 2 of digit II, but with first an insertion to the base of the first phalanx of that digit, which I do not find recorded in my notes on *Leptoptilus*.

*Flexor digitorum profundus*.—Arises fleshy from the second and third fifths of the ulna, very closely connected with the insertion of the ectepicondyloulnaris. The tendon begins where the origin from the ulna ceases, and runs down the radial face of the ulnar carpal under the ligament from the radius to metacarpal II, and then follows the tendon of the superficial flexor to be inserted just beyond it to phalanx 2 of digit II. It receives a strong slip from the short extensor of the thumb, which I did not record in the case of *Leptoptilus*. Gadow mentions somewhat similar relations with the thumb in the case of Owls and *Heliornis*.

*Extensor digitorum communis*.—Arises tendinous from the external condyle of the humerus and passes into a slender belly a quarter way down the forearm, but receives no fibres from the ulna. Its tendon of insertion passes through a groove in the end of the ulna and then sends a branch to the base of phalanx 1 of digit I and a stronger tendon to phalanx 2 of digit II. As in *Leptoptilus*.

*Extensor pollicis longus*.—Two slender fleshy heads from the adjacent surfaces of the radius and ulna at their proximal ends, with accessory fibres from a large part of the length of the radius on its ulnar face. Tendon unites with that of the extensor metacarpi radialis at its insertion. As in *Leptoptilus*.

*Extensor indicis longus*.—One head fleshy from the distal half of the radius and a second much smaller, tendinous from the distal end of the radius and from radial carpal. Insertion to the second phalanx of digit II, but attached by fascia to the first phalanx. As in *Leptoptilus*.

*Interosseus dorsalis*.—Arises fleshy from the opposite faces of metacarpals II and III; fibres run to a centrally placed tendon, like the midrib of a leaf, and this is inserted to the base of the second phalanx of digit II. As in *Leptoptilus*.

*Interosseus palmaris*.—More ventral and stronger than the foregoing muscle but with similar origin and arrangement.

Tendon inserted to phalanx 2 of digit II. In *Leptoptilus* I have noted it as reaching only the first phalanx.

*Abductor indicis*.—Strong muscle arising fleshy from the whole of the radial side of metacarpal II. Inserted to the base of the phalanx 1 of digit II. As in *Leptoptilus*.

*Flexor digiti III*.—Arises fleshy from the ulnar side of metacarpal III and is inserted to the base of the first phalanx of the corresponding digit. As in *Leptoptilus*.

*Adductor pollicis*.—A strong muscle from the metacarpal to the tip of the pollex.

*Extensor pollicis*.—This muscle, which is usually described as single, is represented by two distinct and well-developed muscles, a condition which has been described in the case of *Struthio*, but not in other birds. Most probably, if it were carefully looked for, it would be found elsewhere. The first of the two is a strong slip from metacarpal I and the tendon of the extensor metacarpi radialis to the radial side of the thumb. It is this muscle that gives off a slip to the flexor digitorum profundus. The second muscle is from the head of metacarpal II to the base of the thumb.

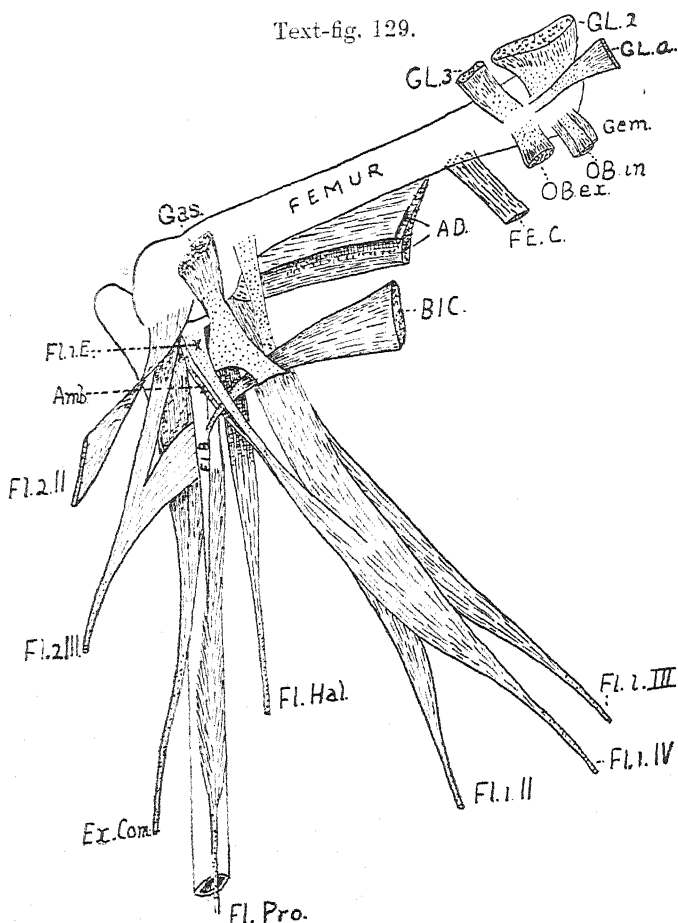
#### MUSCLES OF THE THIGH AND LEG.

*Ilio-tibialis internus (Sartorius)*.—A large and strong strap arising from the anterior and lower border of the ilium and from the fasciæ over the gluteus medius, and closely united along its distal border with the gluteus maximus. Normal insertion to the tibia. I find no notable difference as compared with Storks and Herons.

*Ilio-tibialis (Gluteus maximus)*.—The origin is entirely tendinous and a median tendinous area separates the fleshy anterior and posterior borders. Posteriorly the origin extends backwards half-way over the origin of the biceps, that is to say what Garrod called the post-acetabular part of the muscle, the ilio-tibialis posterior, is present. Garrod tried to use the presence or absence of this in his systematic arrangements, but without much success. It is absent in the Steganopods generally, usually absent in Storks but present in *Ciconia*, absent or very slightly developed in Herons. So far as I can judge, the presence of the post-acetabular portion of this muscle is a primitive condition, and it has been lost or reduced independently in many groups of birds.

*Ilio-trochanterici*.—The externus (text-fig. 129, Gl. 1) and the posterior (text-fig. 129, Gl. 2) are both present in the normal condition. The minimus and quartus are represented by a single tendon of origin and muscular belly (text-fig. 129, Gl. 3). In *Leptoptilus* I found these quite distinct in their origin and insertion; in *Nycticorax* they had a common tendon to the femur but separate insertions to the ilium. These muscles, however, vary so much from bird to bird that I cannot attach any significance to their distinctness or fusion.

Text-fig. 129.

Diagram of Muscles of the leg in *Baleniceps*.

Left leg, external aspect. Tendon is dotted.

FEMUR. Femur. FIB. Fibula.

Gl.a. Ilio-trochantericus externus (Gluteus anterior). Gl.2. Iltroch. posterior (Gluteus minor). Gl.3. Iltroch. anterior et medius (Gluteus minimus and quartus).

Ob.ex. Obturator externus.

Ob.in. Obturator internus, surrounded by Gem., Gemellus.

FE.C. Origin of Femoro-caudal.

A.D. Adductor longus (the upper muscle) and Adductor magnus.

BIC. Insertion of Ilio-fibularis or biceps, passing through a sling.

Gas. External head of Gastrocnemius, cut and reflected to show relation to short arm of the Biceps sling.

Fl.1.II, Fl.1.III, Fl.1.IV. Tendons to respective toes of the Perforated Flexor muscles.

Amb. Ambiens head of Perforated Flexors.

Fl.1.E. External head of Perforated Flexors.

Fl.2.II, Fl.2.III. Perforated and Perforating Flexors of digits II &amp; III.

Fl. Hal. Flexor longus hallucis.

Fl. Pro. Flexor profundus.

Ex. Com. Extensor communis.



*Ilio-femoralis internus* (*Pectineus*).—Strong, little fleshy slip from the ventral edge of the preacetabular portion of the ilium to the back of the femur below the neck. As in most birds.

*Femori-tibiales* (*Crureus* and *Vastus*).—The external muscles are fused to form a common mass; the vastus internus is large, arising from nearly the whole length of the femur.

*Caud-ilio-femoralis* (*Femoro-caudal*).—This is a broad thin strap of muscle arising fleshy from the femur (text-fig. 129, F.E.C.) and running upwards and backwards under the biceps and between the semitendinosus and the semimembranosus and passing to the underside of the tail, where it becomes a thin tendon spreading out into a sheet which meets its fellow of the other side, the combined insertion being to the tendon of the depressor coccygis where that is inserted to the hæmapophyses of the posterior caudal vertebra. There is no accessory femoro-caudal. The accessory fem.-caud. is, I believe, invariably absent in Steganopods, Herons and Storks, although it is present in Spoonbills and the Flamingo. The fem.-caud. itself tends to be degenerate. It is usually present in Storks, but is very slender in *Dissura* and absent in *Leptoptilus*; it is weak in the Herons and absent in several genera.

*Caud-ilio-flexorius* (*Semitendinosus* and *Accessory semitendinosus*).—Origin fleshy from the ischium behind the biceps and extending on to the fascia posterior to the ischium; meets the rather small but distinct accessory or femoral head in a tendinous raphe, and the combined muscles are inserted to the middle belly of the gastrocnemius (text-fig. 130, C.H. 1 & 2). The muscle is much weaker than the semimembranosus.

*Ischio-flexorius* (*Seminembranosus*).—This is the usual broad strap underlying the semitendinosus, and in this case much thicker and wider than the latter. It has a wide origin from the lower edge of the ischium and the fascia over the obturator externus, is unconnected with the semitendinosus, but receives a strong tendinous slip (text-fig. 130, S.I.) from the inner adductor and then is inserted to the tibia by a flat tendon.

*Gastrocnemius*.—There are the usual three heads of which the tibial head is the strongest. The outer head arises from the external condyle of the femur in common with the short arm of the biceps sling (text-fig. 129, Gas.). The middle head is the smallest and arises from between the condyles of the femur by a flat tendon. The tibial head is enormous and arises from the tendon of the ilio-tibialis and from the cnemial crest of the tibia. The three heads unite in the usual way rather less than half-way down the leg to form the tendo achillis.

*Relations of the Caud-ilio-flexorius, Ischio-flexorius, and Gastrocnemius*.—Weldon (38) called attention to the varying relations of these muscles and the differences they presented in Storks, Ducks, and *Phœnicopterus*. I have noted them in a number of Storks and Herons and paid a good deal of attention to them in Gruiform and Limicoline Birds (31 & 32). With minor variations as to the precise interconnections of the

semitendinosus and semimembranosus, the condition which I found in *Baleniceps* seems to be typical in Herons and Storks (text-fig. 130). The middle head of the gastrocnemius is joined by the semitendinosus just after the latter has been met by its accessory. The accessory origin from the femur is parallel to but separate from that of the middle head. The accessory is present in Herons, Storks, *Scopus*, and in *Baleniceps*; it is frequently absent among the Steganopods. In my opinion the middle head of the gastrocnemius is a separated portion of the accessory semitendinosus, and separation of the two, with subsequent disappearance of one or of both, is a secondary or specialized condition.

*Ilio-fibularis (Biceps)*.—Very strong fleshy origin from the whole of the post-acetabular ridge of the ilium to the beginning of the origin of the semitendinosus. The strong belly converges to a rounded tendon which is inserted to the fibula after passing through a sling in the usual way (text-fig. 129, BIC.). The short arm of the sling has a strong anchor to the fibula, which I happen to have noted in Herons, but which is present also in many birds belonging to widely separated groups.

*Ischio-femoralis (Obdurator externus)*.—Arises by strong tendon from external condyle of the femur (text-fig. 129, Ob.ex.) and inserted fleshy to surface of the ischium.

*Obdurator (Obdurator internus)*.—Origin by a strong tendon surrounded by a gemellus muscle (text-fig. 129, OB.in.Gem.) from the external condyle of the femur proximal to the obdurator externus. Garrod (18) believed that in most cases the insertion of this muscle to the inner aspect of the pubis and ischium could be distinguished as oval or triangular, and attached some systematic value to the condition. He described it as oval in Steganopods and Storks and triangular in Herons; in *Baleniceps* it is plainly oval.

*Pub-ischio-femorales (Adductor longus and Add. magnus)*.—The external or longus is only about half the width of the inner or magnus, but their origins and insertions are practically co-extensive. In my notes I find that they were nearly equal in Herons and Storks, but I have not paid special attention to the point. The slips from the magnus to the tibia (text-fig. 130, Sl.) and the slip to the semimembranosus (text-fig. 130) I have not noted in Storks or Herons.

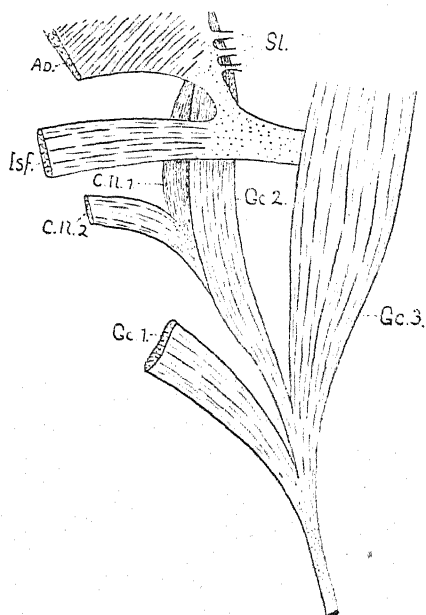
*Peroneus superficialis (longus)*.—Strong muscle from crest of tibia and fascia over the tibialis anticus; usual insertion by broad tendon to the fascia of the ankle and a long tendon running down to join with the tendon of the perforated flexor of the third toe. Precisely the same relations exist in Storks and Herons, but also in so many other birds that no systematic importance can be attached to them.

*Peroneus profundus*.—A short but stout muscle from the tibia below the fibula; its tendon passes over the ankle-joint to be inserted to a knob on the outer side of the tarsus-metatarsus.

According to Weldon and my own notes, this muscle is absent in *Leptoptilus*, but I found it present and with an extension of its origin to the fibula in Herons.

*Tibialis anticus*.—The outer head arises by a strong tendon from the external condyle of the femur and runs in a deep groove to join the fleshy head from the tibial crest. Insertion by a forked tendon to the tarsus-metatarsus, in a pit about an inch below the joint. The conditions are practically the same in Herons and Storks.

Text-fig. 130.

Gastrocnemius and its relations in *Baleniceps*.

- Ad. Adductor magnus    Sl. Tendinous slips from adductor to tibia.  
 Isf. Ischio-flexorius (Semimembranosus).  
 C. Il. 1. Femoral head of Caudilio-flexorius (Accessory Semitendinosus).  
 C. Il. 2. Belly of Caudilio-flexorius (Semitendinosus).  
 Gc. 1, external, Gc. 2, middle, Gc. 3, tibial portion of Gastrocnemius.

*Soleus*.—This little muscle has the usual relations, but is relatively rather stronger than in Storks and Herons; it arises fleshy from the inner side of the tibia and is inserted to the annular cartilage of the ankle-joint.

*Extensor communis digitorum*: arises fleshy from the crest and external surface of the shaft of the tibia (text-fig. 129, Ex.com.). The strong tendon passes through a bony and a fibrous bridge and runs down to the digits where it divides symmetrically into

two, each branch again dividing into two, the four tendons running respectively to the second digit, to each side of the third digit and to the fourth digit. The arrangement is practically identical in Storks and Herons.

*Flexor perforans et perforatus (Flexor secundus)* of digit II.—Origin is from the external condyle of the femur distal to the short arm of the biceps sling (text-fig. 129, Fl. 2 II, p. 680) and from the fascia over the knee-joint, immediately superficial to the corresponding flexor of the third digit with which it is closely connected. The tendon passes in the normal fashion to the second digit, perforating the tendon of the flexor primus and being perforated by the branch of the tendon of the flexor communis.

*Flexor perforans et perforatus (Flexor secundus)* of digit III.—This has two heads, one just deep of the corresponding flexor of the second digit and practically common with it, and a second from the edge of the fibula. Its tendon receives a strong slip from the tendon of the perforated flexor (flexor primus) of its own digit and then is inserted to digit III in the same fashion as the corresponding flexor of digit II. I did not record the existence of the second head of this flexor in my notes on Storks and Herons, but otherwise the flexores secundi have identical relations in *Baleniceps*, Storks and Herons. It must be noticed, however, that these relations are found in a very large number of birds belonging to different groups.

*Flexores perforati (Flexores primi)* of digits II, III, IV; Rudiment of *Ambiens*.—The perforated flexor muscles (text-fig. 129, Fl. 1. II, Fl. 1. III, Fl. 1. IV) are very closely united. Distally the tendons for the respective digits separate out; proximally the common muscular belly arises from three distinct heads and the arrangement is such that fibres to each tendon can be traced to each head. The largest head is fleshy from the intercondylar notch of the femur; there is an outer rather broad tendinous head, superficial to the biceps tendon and arising from the head of the fibula (text-fig. 129, Fl. 1. E). The third head is a round and very distinct tendon, passing under the biceps tendon and running partly to the head of the fibula and partly to the fascia of origin of the flexores secundi (text-fig. 129, Amb.). The inner fleshy head is normal and occurs in practically identical form in all birds that I have dissected. The outer tendinous head also is usually present, and exists in Storks and Herons, the chief differences it presents being in the extent to which it is muscular. In *Baleniceps*, the tendinous portion is longer and the muscular portion relatively shorter than in Storks and Herons, thus showing a degenerate condition. The rounded tendon underlying the biceps is more interesting. In birds where the curious muscle known as the ambiens is present, the tendon of that muscle passes through the knee-joint, passes under the biceps tendon, sometimes with an anchor to the edge of the fibula, and then forms a third head of origin of the perforated flexors,

precisely similar in position and relations to the rounded tendon under the biceps in *Baleniceps*. But for the fact that the tendon stops short at the head of the fibula and does not pass through the knee capsule to a normal ambiens muscle, it cannot be distinguished from the ambiens head of the perforated flexors. Garrod (17) first called attention to the interest of the ambiens muscle and regarded it as a major key to the classification of birds. He divided the Class into two Subclasses, the Anomalogonatae, containing the Piciformes, Passeriformes, and Cypseliformes in which the ambiens is never present, and the Homalogonatae, containing all the other groups of birds and showing that in them the ambiens was normally present. Among the Anomalogonatae there is no species in which the ambiens has been found; among the Homalogonatae there are families and genera in which it is absent, and Garrod believed that in such cases it had been secondarily lost. In a much later contribution to the subject (24), I showed that in the Night Heron and in *Eclectus*, birds without an ambiens but belonging to Garrod's Homalogonatae, there existed an ambiens head to the perforated flexors, absent in the Anomalogonatae, and plainly suggesting that it was a remnant of the ambiens muscle. In a memoir on the anatomy of the Hoatzin (27) I was able to describe from dissections of different examples of that bird, a case of this possible degeneration in actual progress. Garrod had dissected both legs in three examples of the bird and in all cases found the ambiens small but normal above the knees, but in five out of the six legs it was lost at the knee-joint. He does not appear to have had his attention called to the importance of the ambiens head of the perforated flexors. I examined each leg in two examples, and found in every case an ambiens head to the perforated flexors, but the ambiens muscle in some instances absent above the knee, in others small and lost at the knee-joint. It may therefore be taken as established that the ambiens head of the perforated flexors represents a vestige of a complete ambiens muscle, and its existence in *Baleniceps* is of morphological rather than systematic importance. The ambiens is usually present in the Steganopods, present in the Spoonbills, present in some genera of Storks absent in others, absent in *Scopus*, absent in Herons and *Baleniceps*, but in the last two cases its recent loss is shewn by the existence of the vestige to which I have now called attention.

*Flexor profundus* or *perforans* and *Flexor longus hallucis*.—The deep flexor as in Storks and Herons arises by fleshy digitations (text-fig. 129, Fl.Pro.) from the side of the fibula and from down the shaft of the tibia to form a strong round tendon. The flexor longus hallucis comes from the inner surface of the outer condyle of the femur (text-fig. 129, Fl.Hal.) and similarly forms a round tendon. The two tendons pass down to the flexor surface of the foot in the usual way. The deep flexor (text-fig. 131, B) breaks up into a branch for digits 2, 3, 4, and the hallucis tendon,

crossing over the profundus, runs to the hallux, but sends a long slender branch which joins the profundus tendon just before that divides for the digits. The condition corresponds with what Gadow (16, p. 195) calls type I. The hallucis tendon crosses over the profundus to reach the hallux, but sends a vinculum to it. In Storks and Herons the condition is essentially similar, but in the former group the vinculum is stronger and may be in separate slips; in *Scopus* and the Herons the vinculum is much more slender and may be absent. For comparison I figure the condition in a Stork (text-fig. 131, S), a Heron (text-fig. 131, A), and in *Baleniceps* (text-fig. 131, B).

Text-fig. 131.

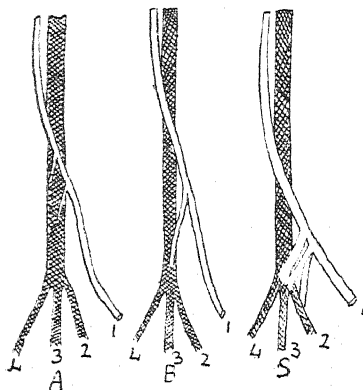


Diagram of Deep Flexor Tendons in A, *Nycticorax*; B, *Baleniceps*; S, *Leptoptilus*.

The *longus hallucis* tendon is in outline, the *flexor profundus* is shaded.

1. Hallux. 2, 3 & 4. 2nd, 3rd & 4th digits.

*Popliteus*.—There was only one of these little muscles stretching across between the head of the fibula and the tibia. In *Leptoptilus* I noted two.

#### SUMMARY OF MUSCULAR ANATOMY.

Garrod's hope, excited by his extraordinarily interesting pioneer work, that muscular anatomy would furnish a sure clue to the classification of birds has not been fulfilled. Garrod relied chiefly on the presence or absence of certain muscles which he found to vary from group to group. Gadow, who has attempted on a complete scale to apply to the system Garrod's group of muscles, using the additional facts made known by Beddard and other writers, appreciated that as these muscles were a common heritage of all birds, the presence of any of them in any group of birds could not be taken as a guide to the systematic position of that

group. He was disposed, however, to attach value to the loss of any of these muscles, and accordingly regarded the loss of this or that muscle as one of the characters to be employed in judging of the relationships of groups. Even this cautious use seems to me to be going too far. At present I do not know of any reason why we should suppose that a particular muscle may not have been lost independently many times; that is to say of any reason why a bird that has lost its femoro-caudal muscle should be more nearly related to another bird with a similar loss than to a bird which has retained the possession once common to all three. The loss is what I have described as a multiradial apocentricity. Possibly when we know as much of the development and morphology of the muscles used by Gaurod, as Fürbringer has taught us in the case of the shoulder and wing muscles, we shall be able to make more definite use of muscular anatomy in systematic ornithology. As, however, muscular anatomy has been used freely, I may give a summary of the chief facts from which more confident anatomists would draw inferences.

Comparison of Herons, Storks, *Scopus* and *Baleniceps*.

Peculiar to *Baleniceps*.

Absence of latissimus dorsi metapatagialis. (? *Scopus*.)

Absence of humeral head of biceps brachii. (Unique.)

Absence of deltoideus minor. (? *Scopus*.)

Absence of teres minor. (? *Scopus*.)

Origin of serratus superficialis posterior confined to dorsad of uncinat processes. (Same in *Phenicopterus*.)

Accessory origin from tip of scapula of serratus metapatagialis.

Common to *Baleniceps* and *Scopus*.

Condition of deltoideus patagialis and patagial tendons.

Expansor secundariorum vestigial or absent (so also in most Steganopods).

Common to *Baleniceps* and Herons.

Presence of peroneus profundus.

Ambiens reduced to a distal vestige (said to be absent in *Scopus*, present in Storks).

Deep flexor tendons.

Common to *Baleniceps* and Storks.

Peculiar arrangement of tendon of insertion of latissimus dors. post.

Practical doubling of pectoralis major (also in some Steganopods).

Presence of post-acetabular portion of glutæus maximus (at least in some Storks; ? *Scopus*).

Oval origin of obdurator internus (also in most Steganopods).

Common to *Baleniceps*, *Scopus*, Herons, Storks and most Steganopods (but also in many other groups).

Absence of biceps slip to patagium.

Absence of accessory femoro-caudal.

Clearly, so far as the evidence from muscular anatomy goes, *Baleniceps* is an ally of *Scopus*, Herons and Storks, and shares many characters with these birds and Steganopods. The two facts that impress me most are the close similarity of the rather highly specialized patagial muscle and tendons in the case of *Baleniceps* and *Scopus*, and the very remarkable condition of the pectoralis thoracicus found in *Baleniceps* and Storks, but which probably also exists in *Scopus*, and certainly in *Pelecanus* and some other Steganopods.

#### OSTEOLOGICAL NOTES.

As the osteology of *Baleniceps* has been described at length in W. K. Parker's well-known monograph (33), and as I have not the time at my disposal to make the elaborate study of the different types of Storks and of Herons which is necessary before final conclusions can be drawn from the skeleton of *Baleniceps*, I must content myself with a few notes on some of the salient points which struck me as requiring special study.

*Occipital condyle*.—In *Baleniceps* this, seen from in front and below, has much the appearance of a moderately dolicocephalic human cranium. It is sessile, elongated antero-posteriorly, and its posterior margin, where it projects slightly into the *foramen magnum*, is convex. In the Herons the condyle is transversely elongated, and the posterior margin, where it projects into the *foramen magnum*, is the broadest part, is concave and slightly grooved, as if to form the beginning of two condyles. In *Scopus* the condyle is also transversely elongated but not so much as in Herons, and its foraminal margin is abruptly truncated. In *Anastomus*, *Dissura*, *Xenorhynchus*, and *Ciconia* the long axis is transverse, and the foraminal margin is concave or notched. In *Tantalus*, on the other hand, the condyle is nearly spherical, and although a notch may just be indicated, the foraminal margin is convex. The configuration of the condyle in *Baleniceps* is, therefore, unlike *Scopus*, Storks or Herons, but it is most nearly approached by the *Tantalus* Storks.

*Paroccipital processes*.—The broad, thin and shell-like processes which bend down over the articulation of the quadrate are repeated on a smaller scale in *Tantalus*, where however the laminae are relatively thicker and less extensive. In other Storks they are replaced by similarly situated, thick and curving ridges. In *Scopus* and Herons all appearance of the shell-like arrangement is absent.

*Basitemporal plate*.—In *Baleniceps* the anterior margin of this has a crescentic free edge which nearly meets at each side a curved lamina projecting from the basisphenoid, so that the Eustachian tubes are nearly floored in below. Parker wrote that "in the Heron these parts are essentially a miniature" of those in *Baleniceps*, adding that this "is certainly not a faint and superficial mark of affinity." But the similarity extends to *Scopus* and



Storks. In Herons the anterior margin is slightly pointed, and in *Scopus* and the Storks, including *Tantalus*, it is rather more sharply pointed, but the general relations and particularly the relations to the laminae from the basisphenoid, which I shall now describe, are more like those of *Baleniceps* in the case of Storks than of Herons.

*Basisphenoid*.—Seen from below this has the usual "T-shaped" appearance, the cross bar of the "T" being contiguous with the anterior edge of the basitemporal, the main limb forming the rostrum. In *Baleniceps* delicate crescentic lamellae project backwards nearly meeting the front edge of the basitemporal plate and with it forming a floor for the Eustachian tubes. The condition of these laminae in *Tantalus* most closely resembles that of *Baleniceps*; in the other Storks the laminae are less complete, and they are least complete in the Herons and *Scopus*. The rostrum from the "T" cross bar to the attachment of the pterygoids is a stout, broad beam of nearly equal width throughout its length in *Baleniceps*. The other birds in the set I am considering present a series ranging from *Baleniceps* through *Tantalus*, the typical Storks, and *Scopus*, to the Herons which present the end of the series most remote from *Baleniceps*. The rostrum gradually in the series changes from an even beam to a sharply contracting, almost triangular outline, and its smooth ventral curved surface becomes first slightly ridged, and then strongly carinate as in Herons.

*Orbital septum*.—This is completely ossified in *Baleniceps*, *Scopus*, all the Storks, including *Tantalus*; very incomplete in the Herons, including *Canceroma*.

*Lacrymal*.—As Parker has described, the lacrymal of *Baleniceps* is highly peculiar, although no doubt the peculiarity is partly adaptive in relation to the enormous beak. It is a stout vertical strut forming the anterior wall of the orbit, firmly ankylosed below with the jugal and maxilla, and above with the nasal. On the roof of the skull it forms the external portion of the fronto-maxillary hinge which runs as a transverse suture across the forehead, being thus entirely anterior to the hinge. A thin vertical lamina projects from it into the cavity of the orbit, which is pierced by a large lacrymal foramen, external to the nasal cavity. In *Scopus* the lacrymal is a vertical beam scooped out on its orbital face for the lacrymal canal, but hanging down freely along the front of the orbital cavity, until it almost meets but does not actually touch the jugal. It has no contact with the maxilla and depends from the orbital edge of the frontal, behind the fronto-maxillary hinge, and with no more than the minutest overlap to the nasal on the distal aspect of the hinge. In Storks of the genus *Tantalus* the lacrymal is suspended from the orbital edge of the frontal behind the hinge, with just a trace of overlap across it to the nasal. From this point of suspension the flat external face hangs vertically downwards, gradually narrowing, and free from the maxilla and not reaching

the jugal below; it has a stout lamina projecting into the orbital cavity transversely to the long axis of the skull and pierced for the lacrymal canal. In the typical Storks and in *Anastomus*, the external face of the lacrymal is roughly triangular, the convex basal line being attached to the orbital edge of the frontal, but definitely extending forwards across the hinge to form a very loose connection with the nasal, not more than a fifth of the whole dorsal edge of the bone. From this, the rapidly narrowing triangle hangs down in front of the orbit and is far from reaching the jugal and has no connection with the maxilla. The inwardly projecting flange is a very thick beam pierced for the lacrymal canal. In the Herons, the relations are a still further exaggeration of the difference between Storks and *Balaniceps*. The outer surface of the lacrymal is triangular with a very broad base of attachment to the frontal behind the hinge, a small loose overlap to the nasal in front of the hinge, and with no connection with jugal or maxilla. The inwardly directed flange is absent and there is no lacrymal canal.

In the case of the lacrymal bone, therefore, *Balaniceps* and *Ardea* stand at opposite ends of a series, *Tantalus* being nearest to *Balaniceps*.

*Nasal region.*—The nostrils in *Balaniceps* are impervious, a stout nasal septum being developed. Gadow states that they are pervious in *Scopus*, but this is a mistake; a very thin lamina of bone very slightly fenestrated separates them. In all the Herons and Storks they are pervious, the cavity from one nostril to the other being large and quite open. The skull is holorhinal as in *Scopus*, *Ardea*, *Cancroma* and all the Storks including *Tantalus*, but in many, especially the larger Storks, the proximal end of the nasal bone shows a line of weakness running up towards the naso-frontal hinge and leading to the schizorhiny seen in *Ibis*. From the anterior border of the nostril a groove runs along the surface of the beak to the extreme anterior end, only the hook of the beak projecting beyond it. Beddard appears to lay some stress (4, p. 434) on this point because he says that the groove is "precisely like that of *Scopus* and *Cancroma*." It is like that of *Scopus*, but in *Cancroma* the groove is much wider and more shallow and does not reach the extreme anterior end. It is much more exactly repeated in the Pelican, the Ibis and the Flamingo. In *Ardea* it is represented by a groove which runs about half-way from the nostril to the anterior end of the beak; and in most of the Storks it is represented by a line of weakness in the bone reaching about half-way to the tip of the beak. This is specially well marked in *Tantalus*.

The nasal processes of the premaxillæ are so firmly fused with the adjacent nasals that their exact outline cannot be seen. It is clear, however, that they do not invade the frontal region but terminate distad of the fronto-maxillary hinge. This also is the case in *Cancroma* and Storks, including *Tantalus*, but in *Ardea*

and *Scopus* the nasals break the transverse line of the hinge, fitting into the frontals.

The anterior tip of the premaxilla is produced in *Baleniceps* to form the strong down-turned hook of the bill. *Scopus* repeats this on a smaller scale; in *Canceroma* the sharp point is not bent into a hook. In the other Herons and in Storks it is straight.

*Palate*.—The palate is desmognathous in *Baleniceps*, the maxillo-palatines being fused in the middle line, and the vomer represented by a triangular, very thin, ossification, the knife-like base of which divides the internal nares when seen from below. The condition in *Scopus* is almost identical, but at its proximal end, where it touches the central laminae of the palatine, the rather larger vomer shows a broader edge with the faintest suspicion of doubling. In the Storks, the vomer is relatively smaller even than in *Baleniceps* and there is no trace of forking. In *Canceroma* and *Ardea* the vomer is relatively very much larger and its edge is quite distinctly cleft between the palatines, each blade being attached to the palatine lamina contiguous with it. In this respect *Baleniceps* and the Herons are at the opposite ends of the series. With regard to the palatines, the most striking feature in *Baleniceps*, fully described by Parker, is the coalescence of the internal laminae to form a strong keel stretching back from the posterior nares to the pterygoid articulations. Allowing for differences in shape and proportion, the similarity with *Scopus* is close. The median keel is still more strongly marked in the Pelican and in *Plotus*; it is represented in Storks by a delicate median ridge, but in *Canceroma* and *Ardea* the internal laminae of the palatines remain completely separate.

*Pterygoids*.—I notice no significant differences between the pterygoids of *Baleniceps* and those of *Scopus*, Storks and Herons. Basipterygoid articular processes are absent in all, and I have not found even any rudimentary trace such as is common in the Pelican. The ventral distal end of each pterygoid is smoothly rounded in *Baleniceps* and *Ardea*; in *Canceroma*, *Scopus* and most of the Storks it shows a sharp keel running out as if to meet the outer lamina of the palatal.

*Quadrate*.—This is substantially alike in *Baleniceps*, *Scopus*, Herons and Storks, but the orbital process in *Baleniceps* is almost triangular, the blunted apex projecting into the orbital cavity. In *Scopus* the orbital process is rather blunter; in *Tantalus* more acute, but in Storks generally it tends to expand to a spatulate end, and in the Herons, including *Canceroma*, the apex is much expanded.

*Quadratojugal bar*.—This is enormously stout in *Baleniceps*, and the separate portions of which it is composed cannot be distinguished. In all the other birds I am considering, it forms a slender, much elongated rod.

*Temporal cavity*.—The boundaries of the temporal cavity present interesting modifications in *Baleniceps* and its allies.

Unfortunately, owing to the very complete union of the bones concerned, these cannot be interpreted completely without the examination of very young skulls, but comparison of adult skulls shows a good deal worth noting. In *Balaniceps* the size of the brain is small in proportion to the size of the bird, with the result that the skull is very short between the orbit and the posterior end. Attachment for the powerful temporal muscle is increased by the strength and size of the postfrontal process (Pl. LXXXI. fig. 1), which depends as a triangle of bone behind the orbit, with the external face strongly ridged. The blunted apex of the triangle reaches nearly half-way down to the quadrato-jugal bar and is continued to a strong tubercle on the latter by a fibrous band. The central portion of the band has a separate ossification, and it would not be surprising to find, in an old bird, that calcification of the fibrous band had joined this central ossification with the postfrontal above and the jugal below, to form a complete beam of bone separating the orbital and temporal cavities externally. Owing to the complete fusion of the bones, it is impossible to be certain as to the exact composition of the postfrontal. A more primitive skull like that of *Dromæus* (in which the proportion of the temporal region to the rest of the skull closely resembles that in *Balaniceps*) shows that the alisphenoid contributes the main portion of the postfrontal, and that the frontal grows down over it only about half-way. In *Balaniceps* it appears as if the frontal covered the alisphenoid right down to the lower end of the postfrontal, and on the posterior face the alisphenoid may itself be covered by a process of the squamosal. On the other side of the temporal cavity in many birds the squamosal sends forwards and downwards from just over the quadrate articulation a stout beam of bone projecting towards the point of the postfrontal. In *Balaniceps* this is represented only by a narrow edge projecting over the quadrate articulation. *Scopus* (Pl. LXXXI. fig. 2) has like *Balaniceps* also a small brain and narrow temporal space. The postfrontal has almost exactly the relations of that of *Balaniceps*, but it does not reach nearly so far towards the jugal. The spur of the squamosal is minute, and allowing for differences in the strength of the muscular attachments, this region is almost the same in *Scopus* and *Balaniceps*.

In a large Stork like *Xenorhynchus* (Pl. LXXXI. fig. 3) there is an arrangement strikingly different in appearance but which, none the less, can be interpreted easily. The brain is still small and the temporal cavity narrow. The postfrontal triangle narrows very rapidly and is continued downwards as a slender bar which stops short long before the jugal is reached. Close scrutiny seems to show that the frontal contributes a superficial splint-like factor, running down almost to the tip on the anterior face, and that the squamosal forms the greater portion of the lower and posterior part, but how much the alisphenoid contributes it is impossible to say. The spur of the squamosal from over the

quadrate articulation is enormous and forms a powerful process which runs downwards and forwards to meet and fuse with the tip of the postfrontal. In a smaller skull, like that of the *Dissura* (Pl. LXXXII. fig. 1), the arrangement is practically identical, but the postfrontal, although it meets the squamosal spur, is much more slender, and the frontal factor does not appear to reach more than half-way down.

In *Tantalus* (Pl. LXXXII. fig. 2) the brain is relatively slightly longer and larger. The squamosal spur is exactly as in *Xenorhynchus* and *Dissura*, but two things have happened to the postfrontal. In the first place it is much shorter, and does not reach the squamosal spur. In the second place the triangular base is very much wider and is deeply notched in front, with the result that it has an anterior and smaller portion corresponding exactly to the anterior margin in all the other birds I have been describing here, but certainly with no squamosal factor, and a longer portion running down towards the point of the squamosal spur, corresponding with the posterior part of the postfrontal in other birds and certainly consisting chiefly of alisphenoid and squamosal factors.

The condition in *Cancroma* (Pl. LXXXII. fig. 3) can now be followed easily. The brain is still larger relatively; the squamosal spur is reduced, and the separation between the two parts of the postfrontal, only just apparent in *Tantalus*, is well marked. The purely frontal, anterior portion is the stouter of the two. In *Ardea* (Pl. LXXXIII. fig. 1), where again the brain is still larger, the squamosal spur is relatively rather small, but the separation between the two parts of the postfrontal is very wide indeed.

As this matter appears to be of some interest, and as I have not found it discussed, I shall continue the description outside the immediate relatives of *Baleniceps*. The Pelican (Pl. LXXXIII. fig. 2) shows a further extension of the series. The squamosal spur is as in *Ardea*, but the two portions of the post-frontal are even further separated, and the posterior of the two is reduced to a mere tubercle, intermediate in position between the squamosal spur and what would normally be taken to be the postfrontal. In *Plotus* (Pl. LXXXIII. fig. 3), which has a very large brain indeed, the squamosal spur is small, there is a mere stump to represent the posterior portion of the postorbital process and this is actually nearer the squamosal spur than it is to the anterior representative of the postfrontal.

I do not suggest that the series, as I have arranged it, is phylogenetic, but it is a striking example of the differences that identical morphological material may exhibit in allied birds, and a warning against the hasty drawing of conclusions as to systematic position from the comparison of one or two presumably allied birds. So far as this point goes, *Baleniceps* and *Scopus* stand together as birds with small brains, with the squamosal spur slight and the postfrontal process simple. Storks form a

second group also with small brains, with the squamosal spur very highly developed, frequently reaching the postfrontal, and with the latter simple, but in *Tantalus* showing the beginning of cleavage. *Cancroma* and the other Herons form a third group, characterized by larger brains, with the squamosal spur reduced as in the first group but with the postfrontal split into two separate processes of which the anterior tends to become the more important.

*Mandible*.—The fusion of the component parts is so complete that I could not see any trace of sutures. The most notable feature is the absence of the projecting spur of the angle, an absence which *Baleniceps* shares with *Scopus*, all the Storks and *Cancroma*, in all of which the end of the mandible behind the articular cavities for the quadrate is as if abruptly sawn off, while in *Ardea* and typical Herons it is produced backwards as a long rounded spur.

*Vertebral column*.—As Parker (33) and Gadow (16, p. 76) have pointed out, there are 17 cervical vertebrae in *Baleniceps*, 16 in *Scopus*, 17 or 18 in Storks, and 18 to 20 in Herons. The carotid canal is complete in all this group of birds. The individual vertebrae are very much shorter antero-posteriorly in *Baleniceps* than in the Herons and *Scopus*; the Storks are intermediate between *Baleniceps* and Herons in this respect, which no doubt is purely adaptive, but it suggests at least that *Baleniceps* is not very closely related with Herons. Parker states that there are no foramina for the vertebral arteries on the sides of the atlas in *Baleniceps* and in its allies. They are certainly absent in *Baleniceps*, but present, although small and limited to the anterior lateral part of the atlas, in *Ardea*, *Cancroma* and *Scopus*, and present and large in Storks.

The thoracic vertebrae have no hæmapophyses in *Baleniceps*, *Cancroma*, *Ardea* and *Xenorhynchus*, but there is a very small unpaired process in *Tantalus*.

*Sternum*.—The posterior lateral processes are very long in *Baleniceps*, projecting well behind the metasternum; in *Scopus*, Herons and Storks, they are short, not projecting behind the metasternum. The notch separating the posterior lateral process from the metasternum is rounded in *Baleniceps*, *Scopus* and Storks, angular in *Ardea* and *Cancroma*. Parker figured a small posterior intermediate process, and compared it with that of the Ibis, but it was completely absent in the skeleton I examined, as well as in Herons, Storks and *Scopus*.

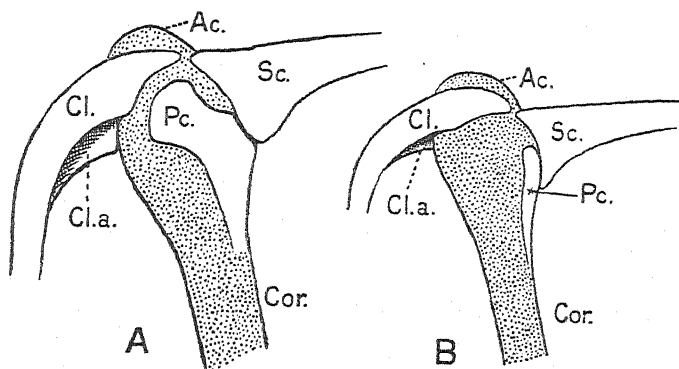
The internal spine of the sternum is absent in *Baleniceps* as in *Scopus*, Storks and Herons, but the external spine is also absent in *Baleniceps*, small in *Scopus*, small or absent in Storks (best developed in *Tantalus*), large and prominent in Herons including *Cancroma*.

*Furcula*.—In *Baleniceps* the clavicles are joined to form a very short-stemmed "Y," the stem of the Y as well as the distal ends of the diverging arms being strongly ankylosed to the

projecting anterior end of the keel of the sternum. There is no trace of a median process opposite the hypocleideum between the arms of the furcula. Anchylosis with the keel may be regarded as an adaptive character. It is as complete in the Pelican as in *Baleniceps*: it exists in some of the large Storks, but in Storks and Herons generally the connection is by ligament. In *Scopus* the furcula is far short of reaching the keel. In *Scopus*, Storks and Herons including *Cancroma*, the furcula is more "U"-shaped; the median forward process between the arms of the "U" is absent in *Scopus* and Storks as in *Baleniceps*, but is well-marked in Herons.

The proximal end of each clavicle where it reaches the coracoid has a very strong flange (text-fig. 132, A, *Cl.a.*) which articulates

Text-fig. 132.

Shoulder-girdle Articulation in *Baleniceps* and *Scopus*.

A. *Baleniceps*.      B. *Scopus*.

- Ac. Acrocoracoid process of Coracoid.
- Cor. Coracoid.
- Pc. Procoracoid process of Coracoid.
- Cl. Clavicle.
- Cl.a. Acrocoracoid process of Clavicle.
- Sc. Scapula.

directly with the anterior border of the coracoid. A similar flange is present in *Scopus* (text-fig. 132, B, *Cl.a.*), and in its place there is a minute flat articular facet in *Tantalus*, but it is absent in Storks generally and in Herons including *Cancroma*, the clavicle being attached to the acrocoracoid only by strong ligaments. The development of this flange in *Baleniceps* is a very strongly marked character, but too much weight cannot be laid on this similarity with *Scopus*, for the acrocoracoid flange of the clavicle is equally well marked in the Pelican, in *Plotus*, in Cormorants and Gannets, and in Birds-of-Prey.

The epicleidial plane of the clavicle passes across the median face of the acrocoracoid and nearly reaches the scapula, with which, however, it is united only by ligament (text-fig. 132, A, *Cl.*). Its tip, however, does not extend so far as to cross the acrocoracoid, and it is therefore wholly concealed when it is viewed from the outer side, the opposite aspect from that shown in text-figure 132. In *Scopus* the tip of the clavicle projects slightly further. In all the Storks and Herons that I have examined the tip of the clavicle projects completely across the acrocoracoid so that its ligamentous connection with the end of the scapula is freely visible when the shoulder-girdle is viewed from the outside.

*Coracoid.*—The basal ends of the coracoid, where they articulate with the sternum, do not quite meet in *Baleniceps*; they either do not meet, or just meet in Storks; in *Scopus* and Herons they overlap.

The procoracoid process (text-fig. 132, A, *Pc.*) is very large in *Baleniceps*, with a curved border nearly reaching an emargination in the clavicle, with which, however, it is united only by ligament. This process varies in Storks, being almost as large but not expanded in some, small in others (e. g. *Tantalus*). It is quite small in *Scopus* (text-fig. 132, B, *Pc.*) and Herons including *Canceroma*.

*Pelvis.*—Parker lays some stress on the narrowness of the pelvis in *Baleniceps*, comparing it in this respect with Herons and contrasting it with Storks. Certainly such a difference does exist, but as it was not so striking to my eye as Parker found it, I measured a number of pelves of Storks and Herons, reduced the measurements of the narrowest and widest portions of each to a common standard and averaged the results.

#### Width of Pelvis in percentage of length.

	Narrowest part.	Widest part.
<i>Baleniceps</i> .....	27	50
<i>Ardea</i> .....	25	50
<i>Canceroma</i> .....	28	57
<i>Xenorhynchus</i> ...	35	60
<i>Tantalus</i> .....	35	56
<i>Scopus</i> .....	37	62

It will be seen that the width at the widest part differs much less than the width at the narrowest part. In other respects I find that the pelvis of *Baleniceps* is rather more like that of *Scopus* and Storks than of Herons. There is a well-marked notch separating the distal ends of the ilium and ischium in *Baleniceps*, *Scopus*, and Storks which is absent in Herons, including *Canceroma*. In Herons, including *Canceroma*, the dorso-lateral edge of the post-acetabular ilium projects outwards as a sharp horizontal ridge, which is very slightly marked in *Scopus* and is absent in *Baleniceps* and Storks.



*Humerus*.—A good deal of attention has been paid to the anterior surface of the proximal end of the humerus in birds, and I have compared the conditions presented by *Baleniceps*, *Scopus*, Storks and Herons. *Baleniceps* is markedly different in this respect from the others and resembles much more closely the structure shown by the same bone of the Pelican, which has been adequately figured by Pycraft (35, fig. 6, p. 90). The expanded end of the humerus is very flat and rather symmetrical. The coraco-humeral groove is extremely faint, rather better marked than in the Pelican but entirely different from the deep transverse groove shown by *Scopus*, Storks and Herons. The crista inferior is hardly raised above the surface; only the faintest distal groove separates it from the shaft of the bone. In the Pelican it is much more salient; Pycraft's figure rather under-represents its prominence. In Herons the crista is rather like that of *Baleniceps*, but more prominent; in *Scopus* it is still more prominent, and in Storks, including *Tantalus*, it is even more prominent. The pectoral crest is still longer and better marked in *Baleniceps* than in the Pelican, but is generally similar, and in both the oval impression for the insertion of the second division of the pectoral is very clear. There is no trace of this in the Herons. In the Storks, including *Tantalus*, it is well-marked. This region of the humerus in *Scopus* is characterized by the enormous development of the pectoral crest, which is very much larger than in any other of the birds with which I am dealing here, and there is a faint oval impression which certainly seems to imply the existence of a divided pectoral in that bird, as in Storks and *Baleniceps* (see *supra*, p. 676).

*Hand*.—The hand of birds is usually described as containing the representatives of three digits, of which that corresponding with the index finger (on the usually accepted supposition that the pollex is present) is the largest. The proximal phalanx of this digit has usually a broad flange on the ulnar side on which one or more of the primary quills rest. In dissecting this region in *Baleniceps* I was struck by the way in which the arrangement of muscles suggested that this phalanx represented the phalanges of two adjacent digits united by a narrow sheet of bone. On examining the skeleton in *Baleniceps* itself, *Scopus*, *Ardea* and a number of Storks, the suggestion is still more striking. The broadened phalanx is obviously thickened along the ulnar and radial borders, and if these borders were the phalanges of two digits united by an ossified sheet of fibre the structure would be intelligible. The point requires investigation, both by comparative anatomy and embryology, and I mention it here, only to direct attention to it, but I shall be surprised if it does not turn out that the hands of these and many other birds show four not three digits.

*Tibial bridge*.—The bony canal for the tendon of the extensor muscle of the digits is complete in *Baleniceps* as in *Scopus*, Storks and Herons.

*Tarsal bridges*.—The hypotarsus is complex in *Baleniceps*, *Scopus* and Herons; that is to say the proximal end of the shaft is provided with two bony bridges through which the flexor tendons pass; in Storks these bridges are absent, and the tendons lie in a groove.

#### SUMMARY OF OSTEOLOGICAL NOTES.

There is a strong general resemblance between *Baleniceps*, on the one hand, and *Scopus*, Herons and Storks on the other. *Baleniceps* stands alone in its general proportions, in the structure and relationship of the lacrymal, quadratojugal bar, atlas, posterior lateral process of the sternum, and the humerus.

*Baleniceps* and *Scopus* agree, opposed to the others, in the impervious nostrils, the union of the inner plates of the palatines, the processes bounding the temporal cavity, the acrocoracoid articulation of the clavicle, and the shortness of the tip of the clavicle.

*Baleniceps*, *Scopus* and Storks agree, opposed to the others, in the basi-temporal plate, the complete interorbital septum, the very small vomer, the shape of the posterior notch of the sternum, the absence of a spina interna, and of a median process between the diverging arms of the furcula, and the presence of a notch separating the posterior extremities of the ischium and ilium.

*Baleniceps* and Storks agree, opposed to the others, in the large procoracoid, and the smooth edge of the post-acetabular ilium. Of the Storks, *Tantalus* shows the closest agreement with *Baleniceps* in the occipital condyle, the paroccipital processes and the basisphenoid.

*Baleniceps* and Herons and *Scopus* agree, to the exclusion of the others, in the proportions of the pelvis, and the complex hypotarsus.

I have been unable to find any osteological points in which *Baleniceps* agrees with Herons to the exclusion of the others.

#### SYSTEMATIC POSITION OF *BALENICEPS*.

John Gould (22) named and diagnosed this bird in 1851. He relied on external characters and compared it carefully with *Pelecanus*, *Grus*, *Ardea* and *Canceroma*. He came to the conclusion that it was the "Grallatorial type of the *Pelecanidae*." He rejected alliance with *Ardea* and *Canceroma* apparently because in the latter the nail of the central toe is pectinated, a character which he thought to be wholly absent in *Baleniceps*. I have shown (*supra*, p. 648) that much reliance cannot be placed on this character. Undoubtedly there are many marked anatomical characters common to *Baleniceps* and the Pelican. I may mention the presence of a pyloric chamber of the stomach; the division of the great pectoral muscle; the condition of the

tendons of the wing; the absence of intrinsic muscles in the syrinx; the long lacrymals; the fusion of the internal laminae of the palatines; the shell-like paroccipital processes; the ankylosis of the clavicle to the keel of the sternum; the shape of the head of the humerus. But these can probably be best explained either as convergent modifications in birds which, after all, are not very far apart in the system, or the common inheritance of Steganopods and their immediate allies. Subsequent writers on *Baleniceps* appear to have been dominated by the wish to prove Gould incorrect. J. Reinhardt (37) in 1860 came to the conclusion that the nearest ally of *Baleniceps* was *Scopus*, and that *Scopus* and *Baleniceps* together were nearer the Storks than the Herons. He appreciated that the pterylosis, especially of the neck, was similar in *Baleniceps*, *Scopus* and Storks and markedly differed from that of *Canceroma* and the other Herons. He attached importance to the pectination on the claw of *Canceroma* and the Herons; noted that there was an approach to it in *Scopus*, but did not recognize that it also occurred in *Baleniceps*. He noted that the inter-orbital septum was complete in *Scopus* and Storks, incomplete in *Canceroma* and Herons, but had not information on that point in the case of *Baleniceps*. He compared the bills in considerable detail, and pointed out essential points in which *Baleniceps* and *Scopus* agreed, and differed from *Canceroma*. Parker (33) read his great paper before Bartlett's contribution, but as the latter was actually published first, it is more correct chronologically to take Bartlett (1) first, although, curiously enough, the authors quote one another, and each relies on the other's opinion. Bartlett in 1861 made the interesting discovery that *Baleniceps* had a pair of large powder-down patches on the back, and this for him settled the Ardeine affinities of the bird. He included, however, *Eurypyga* amongst the Herons, and I have shewn (*supra* p. 645) that in the present state of our knowledge, the presence of powder-down patches is no conclusive evidence as to affinity.

I cannot understand why it has been assumed and stated by writers who had an opportunity of reading the memoir, that W. K. Parker's osteological examination proved *Baleniceps* to be a Heron and not a Stork. In the Introduction to his memoir, he made the following general statement:—"It is to the stilted, wading group of scavengers that *Baleniceps* belongs, being one of the *Ardeae affines*, and therefore intimately related to the White Stork, the Marabout, and the Adjutant. Its nearest relations, however, are the South American Boat-bill (*Canceroma cochlearia*) and the Little South African Umbre (*Scopus umbretta*)."

In a footnote to his paper he refers to Bartlett's discovery as "having proved beyond all dispute, that the *Baleniceps*, like the Boat-bill, is essentially a Heron." But these are *ex cathedra* statements. He also gives a list of what he regards as "Ardeine genera";—including *Ciconia*, *Leptoptilus*, *Mycteria*, *Anastomus*, *Aramus*, *Ardea*, *Botaurus*, *Herodias*, *Nycticorax*, *Scopus*,

*Cancroma* and *Baleniceps*. He selected the Heron as the type-form as "it is best known, and has the characters of the family moderately, but markedly developed." In his detailed examination, he is quite as concerned to prove that *Baleniceps* is like *Scopus* or like a Stork as like a Heron. He came to the very definite conclusion that *Baleniceps* was not a Pelican, but was Ardeine, in his broad sense of the word. Quite certainly he did not prove it to be a Heron as opposed to a Stork; and in this I entirely agree, after having gone through his own observations with the skeletons before me, and having made some further comparisons myself.

C. G. Giebel (21) in 1873 re-opened the matter, chiefly after a full examination of the pterylosis and external characters. He corrected Gould and Reinhardt (not quoting the latter, however) as to the pectination, describing it carefully and showing that it was present in *Baleniceps* in much the same form as in *Scopus*. He showed also that these birds agreed in pterylosis, where they differed from *Cancroma*, and came to the conclusion that *Baleniceps* was much more closely allied with *Scopus* than with *Cancroma*.

F. E. Beddard in a special memoir and in his treatise on the anatomy of birds (3 and 4) assumed that Parker's osteological researches had proved *Baleniceps* to be a Heron, not a Stork, overlooked the evidence supplied by Reinhardt and Giebel as to the Stork-like pterylosis of *Baleniceps* and *Scopus*, and although he referred to Giebel's paper, did not note that Giebel showed *Baleniceps* and *Scopus* to be alike in the pectination of the claw. He placed *Baleniceps* definitely among the Herons as opposed to the Storks, relying apparently chiefly on the syrinx. I have already stated (*supra* p. 651) that his argument cannot support his conclusion. Possibly it may show that *Baleniceps* is not a Stork; it does not show that it is a Heron.

H. Gadow (16) placed both *Baleniceps* and *Scopus* under the Ardeæ as opposed to the Ciconiæ, but placed *Baleniceps* merely as a sub-family of the Herons, distinguished from the true Herons by the absence of pectination and various minor characters. He was misled, I think, by the literature, and does not claim to have made independent observations.

Those who have followed the old and new facts regarding *Baleniceps* that I have been able to bring together must be impressed by the number of characters in which *Scopus* and *Baleniceps* agree, and by the much greater number of points in which these two birds agree with Storks than with Herons. If we adopt the method made familiar by many of those who have written most copiously on the anatomy of birds, take characters on their face value, and regard those birds as most nearly allied which have the greatest number of characters in common, then the sub-order Ardeæ will contain the single family Ardeidæ, and the adjacent sub-order Ciconiæ will comprise the families Scopidæ,

Balænicæpididæ, Ciconiidæ and Ibiidæ. But if we desire that classification should represent phylogeny, we must await further knowledge as to the value of the various characters which anatomists have tried to use. It is no use bringing pectination or powder-down patches, or a completely feathered neck into an argument between Storks and Herons, if these characters have been independently acquired or independently lost in the case of many different groups. It is no use for systematic purposes to call a particular form of syrinx Ardeine if that be a common type in many different kinds of birds, or to call a doubled pectoral muscle Ciconine if that be shared by many Steganopods. The fact is that Steganopods, *Scopus*, *Balænicæps*, Storks and Herons have a large common heritage, consisting partly of actual common structures (some of which they share with a very much larger assemblage of birds) and partly of the capacity to be modified in certain definite directions. The characters latent and patent composing this common heritage are distributed irregularly amongst them, partly for reasons that we do not know and partly in response to similar habits. Until the meaning and history of each set of characters have been worked out very fully we have less than no idea as to their real value in indicating affinity. The only set of characters on which I have sufficient knowledge to have any confidence is shown in the disposition of the alimentary tract. In that respect *Balænicæps* seems to me to have passed through the condition common to Storks and Herons, and to display specialization in the same direction as the Herons. But until we have further knowledge, not so much of *Balænicæps* in particular, but of the value of anatomical characters, the safe course is to regard *Balænicæps* as the representative of a group of equal value with Storks and Herons.

In my opinion, however, the relation of Storks and Herons to the Steganopods requires revision. Pending this, I must add that John Gould's description of *Balænicæps* as the "Grallatorial type of the Pelecanidæ" is at least as happy as the more confident statements of later writers.

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## EXPLANATION OF THE PLATES.

## PLATE LXXX.

*Baleniceps rex*. From a living young male.

Photo by D. Seth-Smith, F.Z.S.

## PLATE LXXXI.

Fig. 1. Side of Skull in *Baleniceps*.2.       "       "       *Scopus*.3.       "       "       *Xenorhynchus*.

## PLATE LXXXII.

Fig. 1. Side of Skull in *Dissura*.2.       "       "       *Tantalus*.3.       "       "       *Canceroma*.

## PLATE LXXXIII.

Fig. 1. Side of Skull in *Ardea*.2.       "       "       *Pelecanus*.3.       "       "       *Plotus*.

44. The Classification and Phylogeny of the Calcareous Sponges, with a Reference List of all the described Species, systematically arranged. By ARTHUR DENDY, D.Sc., F.R.S., F.Z.S., Professor of Zoology in the University of London, and R. W. HAROLD ROW, B.Sc., F.L.S., Assistant Lecturer and Demonstrator in Zoology at King's College.

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(Text-figure 133.)

"Le groupe ne se définira plus par la possession de certains caractères, mais par sa tendance à les accentuer."—*Bergson*.

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## INTRODUCTION.

The first Calcareous sponges, "*Spongia ciliata*" and "*Spongia compressa*," were described in 1780 by Fabricius, but it was not until much later that the essential differences between the Calcareous and Non-calcareous Sponges were recognised. Fleming, in 1828, however, proposed the genus *Grantia* for the former group, including in it all the forms whose skeleton consisted of calcium carbonate. (Risso's earlier genus, *Sycon*, and Gray's *Scypha* were diagnosed differently.)



The next important advance in the history of the group was the erection of the genus *Leucosolenia* by Bowerbank in 1866, for certain sponges which we now include in the Homocelidae, in addition to other genera no longer employed. From that time forward numerous investigators studied the group, and many new species and several new genera were described, but no really serious attempt to deal with the question of the classification of these sponges was made until the time of Haeckel, who in 1870 published his 'Prodrömus,' and in 1872 his famous Monograph of the group, with extremely detailed, though somewhat unsuccessful descriptions of all the then known species, including many which he described for the first time. Haeckel's so-called "natural" system, with its three families of Ascones, Leucones, and Sycones, based upon the type of canal system, and its twenty-one genera based upon the types of spicules present, is so well known, and has been so often criticised, that it needs no further description by us, especially as it proved extremely artificial, and expressed only to a very limited extent the true phylogeny of the group.

The scheme proposed by Poléjaeff in 1883 was considerably more successful, and his primary division of the group into HOMOCÉLA and HETEROCÉLA has been made the basis of almost every classification since proposed. We are now beginning to realise, however, that this division also is of a very arbitrary character.

The next scheme of classification we need notice is that of Vosmaer, in Bronn's 'Klassen und Ordnungen des Thierreichs' [1887], which is almost identical with that of Poléjaeff, with the addition of the Pharetronidae as a fourth family of the HETEROCÉLA.

In 1891 von Lendenfeld proposed a modification of Haeckel's system, erecting a fourth family, the Syllieibidae, intermediate in canal-system between the Leucones and Sycones, and reducing the number of genera in each family to two, according to the presence or absence of oxea. This was undoubtedly a considerable improvement upon Haeckel's system, but again it failed to interpret the interrelationships of the members of the group correctly, and it has since been almost entirely abandoned, though certain spongologists, notably Breitfuss, retained it with but little modification for a considerable time.

During the years 1891-1893 there was published by Dendy [1891 A, 1892 B, 1893 A] a scheme of classification based on almost wholly different lines. Retaining Poléjaeff's Orders HOMOCÉLA and HETEROCÉLA, and, like that author, including in a single genus, *Leucosolenia*, all the species of HOMOCÉLA, he divided the HETEROCÉLA into five families, whose differentiating characters were based far more on the structure and arrangement of the skeleton than on the canal system; and although this system has not been accepted by all writers, yet we ourselves feel that it embodies a more natural arrangement of the group than

any of its predecessors, and we have made it the basis of the classification here proposed.

In 1896 Minchin published a paper entitled "Suggestions for a Natural Classification of the Asconida," which may fairly be said to mark a new departure in the taxonomic study of the Calcarea, in that it introduces for the first time the idea of the position of the nucleus in the collared cell as a character of taxonomic importance, a character which has since proved, in our opinion, to be of great value. We have not been able, however, to follow Minchin completely in those modifications of Dendy's classification of the group which he proposed, partly in the paper referred to, and partly in his well-known article in Lankester's 'Text-book of Zoology' [1900].

In 1898 Bidder, in a paper on "The Skeleton and Classification of Calcareous Sponges," proposed to carry out Minchin's ideas with regard to the nucleus of the collared cell to their logical conclusion, and to divide the Calcarea into two great groups accordingly—CALCARONEA and CALCINEA. Although not actually adopting this division, which we consider to be somewhat premature in the present state of our knowledge, we have ourselves followed much the same line of cleavage. Although he accepts to a large extent, with regard to his families, the system proposed by Dendy [1892 B], Bidder makes certain rearrangements which do not appear to be altogether satisfactory. He does good service, however, in indicating for the first time the relationship of Carter's *Clathrina tripodifera*, for which he proposes the genus *Dendya*, to Haeckel's *Leucaltis clathria* (= *Heteropogmia nodus-gordii* Poléjaeff). In the same paper he discusses the position of the crystalline optic axis of the radiate spicule systems, and endeavours to assign taxonomic value to this character also, but whatever may be the theoretical value of his conclusions, which have since been accepted by Minchin [1909], we cannot consider that such a character is of any practical use to the systematist.

In 1908 Jenkin erected two new families, the Chiphoridae and Staurorhaphidae, supposed to be differentiated by the presence of what he considered to be a new type of spicule, the "chiactine," from all previously recognised families. The peculiarity of these spicules was believed to consist in the orientation of the various rays both in relation to one another and to the other parts of the skeleton, and a special method of development was suggested for them. Finally, in 1909, one of us (Row) still further elaborated the "Chiact Theory," as it was called, and proposed yet another family, the Grantillidae, in which more primitive, but similar, "prochiacts" were supposed to be present, and which was made by him the starting-point from which the Heteropiidae were supposed to have been derived. As we shall show later, however, we do not now think that the spicules in question are more than very slight modifications of ordinary types, and we have abandoned all three families.

It is now more than forty years since any attempt was made at a complete revision of the Calcarea, and in the interval the number of known species has increased from 111, described in Haeckel's 'Kalkschwämme,' to 436 recognised by us at the present time. Having recently been engaged in examining collections of Calcarea of considerable importance and extent, we have had impressed upon us the necessity for a complete systematic catalogue of all the known species, the descriptions of which are scattered through an immense number of separate memoirs. In order to supply this want we have had to go through practically the whole of the literature of the group, and there is not a paper, to the best of our belief, which contains a reference to a new species which we have not seen. It is with considerable satisfaction that we find, as a result of this work, that the scheme of classification proposed by one of us twenty years ago [Dendy, 1892 B] is still applicable in its essential respects, and requires comparatively little revision in order to bring it up to date.

In the present memoir we propose to give diagnoses of all the families and genera employed, and to enumerate all the known species under the genera to which we assign them. We have decided to confine ourselves to the consideration of living forms, since our knowledge of fossil sponges is at present so unsatisfactory, and the number of described species so great.

We have had access, during the course of our work, to a large amount of material, comprising a large proportion of the known species. This has consisted chiefly of the collections in the Natural History Department of the British Museum, a large collection brought by one of us from Australia (see Dendy [1891 A and 1892 B]); the collections made by Mr. Cyril Crossland in the Red Sea (see Row [1909]), Zanzibar (see Jerkin [1908 A]), and Cape Verde (see Thacker [1908]); a collection made by the 'Sealark' Expedition in the Indian Ocean (see Dendy [1913]); and the magnificent collection made by the Hamburg South-Western Australian Expedition in 1905 (see Row [1913 MS.]). In addition, one of us (Row) visited Berlin and Jena in 1912, and obtained valuable information from the study of type specimens at those places.

With regard to the difficult question of synonymy, and the limits which should be assigned to each species, we have, nevertheless, been obliged to rely in most cases upon the published descriptions and determinations of the authors responsible, and we have unfortunately found that these descriptions are frequently very inadequate; while even where they are more complete, the fact that they have been prepared from the point of view of a different scheme of classification has sometimes made them difficult to use. We have, however, assumed that all descriptions are correct, except in cases where they have been shown by subsequent authors, from an investigation of type

specimens, to be erroneous. Further, we have felt that we could not, merely on the basis of these published descriptions, undertake the responsibility of determining whether or not a species described as new by its author should more properly have been allocated to a previously known species. Thus we have proceeded on the principle that all species described as new must be considered to be distinct, unless they have been proved to belong to a previously known species by the subsequent reinvestigation of type specimens or otherwise. We have only given such synonyms and references as seem absolutely necessary, but where one species has been merged in another by any authority, and this result accepted by us, we give the synonym and the appropriate authority under the species in which it is now placed.

It is thus highly probable that, of the 436 species which we enumerate, a considerable proportion will ultimately prove to be identical with one another. This question, however, can only be decided by a very thorough study of the specific characters and range of variation in each case, probably necessitating in many cases a reinvestigation and comparison of the original types. Professor Minchin, in his paper on "The Characters and Synonymy of the British Species of Sponges of the genus *Leucosolenia*" [1905], has set a good example of the manner in which this critical revision of the group ought to be carried out.

We have, as a general rule, taken no notice of varieties as distinct from species, but certain of Haeckel's so-called "Specific Varieties," to which he has already given distinctive names, appear to us, after careful consideration of his descriptions, to deserve to rank as separate species.

In the preparation of this paper we have throughout borne in mind the requirements of the systematist, and it is hoped that its publication will greatly assist the determination and arrangement of species in the future. We have had to set aside a great number of published generic names as synonyms, but it is hoped that the appended list will enable the student to trace them in the present system.

We have indicated in the list of species under each genus that species which we recognise as the type, our method of procedure being to take, in the case of old genera, that species, of those which we assign to the genus, to which the name of the genus was first applied, while in the case of new genera we have chosen as our type the species which seems to exemplify best the special characters on which we have founded the genus.

As the publication committee of the Zoological Society has decided against the use of brackets around the names of authors of species in all cases, it must be understood that the authors cited are responsible for the specific but not necessarily for the generic names employed by us.

## PRINCIPLES OF CLASSIFICATION.

It appears to us that the chief point to be borne in mind in attempting to arrive at any natural system of classification is the importance of utilising as many characters as possible. A classification based upon a small number of characters must necessarily be arbitrary and artificial, and characters which are of great importance in some cases may be of comparatively little use in others. There can be no doubt that there are certain significant characters which do indicate genetic relationships, but these characters are by no means the same in all cases, and they have to be carefully sought for and distinguished amidst a host of less important features. Sometimes it is the canal system that affords the best clue, sometimes the arrangement of the skeleton, sometimes the form of the spicules, and sometimes even the position of the nucleus of the collared cells. There must also be remembered the undoubted fact that the phenomenon of convergence has played a large part in the evolution of the Calcarea, and has led in many cases to totally deceptive resemblances, as, for example, between the genera *Leucetta* and *Leucandra*.

It seems likely, however, that the collared cell, or choanocyte, which itself is by far the most characteristic histological constituent of the sponge organisation, may ultimately prove, as suggested by Bidder [1898], to afford a means of dividing the whole of the Calcarea into two main branches, one having the nuclei of these cells placed basally, and the other having them apical. Indeed, the acceptance of this principle, if only in a tentative manner, constitutes the chief difference between our present views on the subject and those which we previously held; but in the present state of our knowledge it is a principle which must not be pushed too far, and we have only been able to make use of it as subsidiary to more easily determined characters. The acceptance of this principle, however, necessitates the wide separation of the Lelapiidæ from the other Pharetronid sponges with which they have hitherto been associated.

We shall discuss this question in some detail later on, but it may serve a useful purpose if we give at once a list of all the species of Calcarea in which we have been able to determine the position of the nucleus, and the results of our determination. This list includes no less than 75 species, as follows:—

## Nuclei apical.

## Nuclei basal.

## Family HOMOCCELIDÆ.

<i>Leucosolenia bella</i> Row.	<i>Leucosolenia falcata</i> Haeckel.
<i>Leucosolenia complicata</i> Montagu,	<i>Leucosolenia stolonifer</i> Dendy.
<i>fide</i> Minchin.	<i>Leucosolenia ventricosa</i> Carter.
<i>Leucosolenia lucasi</i> Dendy.	<i>Leucosolenia gardineri</i> Dendy.

## Nuclei apical.

## Nuclei basal.

## Family HOMOCCELIDÆ (continued).

- Leucosolenia variabilis* Haeckel, *Leucosolenia coriacea* Montagu,  
*fide* Minchin. *fide* Minchin.  
*Leucosolenia depressa* Dendy.  
*Leucosolenia cavata* Carter.  
*Leucosolenia pelliculata* Dendy.  
*Leucosolenia proxima* Dendy.  
*Leucosolenia pulcherrima* Dendy.  
*Leucosolenia vitrea* Row.  
*Dendya tripodifera* Carter.  
*Ascute uteoides* Dendy.

## Family LEUCASCIDÆ.

- Leucascus simplex* Dendy.  
*Leucascus insignis* Row.  
*Leucascus clavatus* Dendy.  
*Leucetta chagosensis* Dendy.  
*Leucetta expansa* Row.  
*Leucetta microraphis* Haeckel.  
*Leucetta prolifera* Carter.  
*Leucetta pyriformis* Dendy.  
*Pericharax heteroraphis* Polé-  
jaeff.  
*Pericharax peziza* Dendy.

## Family LEUCALTIIDÆ.

- Leucaltis clathria* Haeckel.  
*Leucettusa dictyogaster* Row.

## Family MINCHINELLIDÆ.

- Minchinella lamellosa* Kirk-  
patrick.

## Family MURRAYONIDÆ.

- Murrayona phanolepis* Kirk-  
patrick.

## Family SYCETTIDÆ.

- Sycon boomerang* Dendy.  
*Sycon carteri* Dendy.  
*Sycon gelatinosum* de Blainville.  
*Sycon giganteum* Dendy.  
*Sycon lendenfeldi* Row.  
*Sycon ramsayi* von Lendenfeld.  
*Sycon raphanus* O. Schmidt.  
*Sycon setosum* O. Schmidt.  
*Sycon verum* Row.

## Nuclei apical.

## Nuclei basal.

## Family HETEROPIIDÆ.

- Grantessa erinaceus* Carter.  
*Grantessa hastifera* Row.  
*Grantessa hispida* Carter.  
*Grantessa poculum* Poléjaeff.  
*Grantessa polyperistomia* Carter.  
*Grantessa sacca* von Lendenfeld.  
*Grantessa intusarticulata* Carter.  
*Heteropia glomerosa* Bowerbank.  
*Heteropia simplex* Row.  
*Vosmaeropsis dendyi* Row.  
*Vosmaeropsis depressa* Dendy.  
*Vosmaeropsis macera* Dendy.  
*Vosmaeropsis primitiva* Row.  
*Vosmaeropsis wilsoni* Dendy.

## Family GRANTIIDÆ.

- Grantia compressa* Fabricius.  
*Grantia genuina* Row.  
*Grantia vosmaeri* Dendy.  
*Grantia indica* Dendy.  
*Teichonopsis labyrinthica* Carter.  
*Grantiopsis infrequens* Carter.  
*Ute syconoides* Dendy.  
*Ute spiculosa* Dendy.  
*Synute pulchella* Dendy.  
*Leucandra hispida* Carter.  
*Leucandra australiensis* Carter.  
*Leucandra echinata* Schuffner.  
*Leucandra meandrina* von Lendenfeld.  
*Leucandra minima* Row.  
*Leucandra phillipensis* Dendy.  
*Leucandra thulakomorpha* Row.  
*Aphroceras cataphracta* Haeckel.

## Family AMPHORISCIDÆ.

- Amphoriscus oblatu*s Row.  
*Leucilla australiensis* Carter.  
*Leucilla princeps* Row.

## Family LELAPIIDÆ.

- Lelapia australis* Gray.

With the exception of this important feature, which in the main harmonises very well with our previous conclusions, the principles that we have followed in arriving at the classification set forth in the present paper are almost exactly those which

were expounded by one of us some twenty years ago [Dendy 1891 A, 1893 A], as the following review of our present position will show.

The canal system, including the form of the flagellate chambers, is, we are convinced, of comparatively little taxonomic value in the higher Calcarea. In the lower forms it necessarily determines the arrangement of the skeleton, which must lie in the walls of the ascon tubes, however these may be arranged, and in the Sycetidae the arrangement of the radial tubes has undoubtedly been the determining factor in the development of the articulate tubar skeleton. With the appearance of a definite dermal cortex, however, the arrangement of the skeleton begins to vary more or less independently of the canal system, so that with an identical canal system we find such different types of skeleton as that of the Grantiidae, the Heteropiidae and the Amphoriscidae. In each of these families, while the type of skeleton remains fairly constant, the canal system ranges from syconoid to leuconoid, or at least sylleibid. The syconoid type is again met with on a totally different line of descent in the homocæl genus *Dendya*, and also in *Leucaltis*, and again gives rise to a leuconoid type both in the Leucascidae and the Leucaltidae.

Our view that it is the canal system rather than the skeleton that has repeatedly undergone convergent evolution is strongly supported by the distribution of the different types of spicules and of the two types of collared cells. The form of the spicule, however, must be used with great caution as a guide to genetic relationships, for it is largely a question of adaptation. The triradiate is undoubtedly the fundamental spicule form in the group, but one might almost say that it tends to become quadriradiate on the slightest provocation. Thus we almost invariably find quadriradiates in the gastral cortex, whose inwardly directed apical rays are undoubtedly of great value as a protection against enemies, such as small crustaceans, approaching through the osculum. Then, again, the ordinary triradiates of the dermal cortex not infrequently develop a more or less conspicuous, centripetally directed, apical ray; and this latter tendency appears to have led, in the case of the Amphoriscidae, to a constant skeletal character which forms the most characteristic feature of the group. Similarly with regard to the distinction between equiangular and sagittal triradiates, we find that the latter can always be developed, when the situation in the sponge demands this form, by the bending back of the oral rays during growth. This nearly always takes place, for example, in the oscular collar, where there is no room for the oral rays to extend forward at the usual angle.

Whether or not there is a fundamental difference between an equiangular triradiate, however its rays may be bent, and an alate one in which the primitive oral angle is really different from the paired angles, and in which there is a corresponding difference in the position of the crystalline optic axis, as



maintained by Bidder and Minchin, is another and much more difficult question to decide. The presence of regular equiangular triradiates seems most certainly to be very characteristic of the Leucascid-Leucaltid line of descent, and we have made use of it as one of the distinguishing features of the members of those groups. It is, however, extremely difficult in practice to distinguish between a sagittal spicule which owes its sagittal character merely to the backward bending of the oral rays, and one which is sagittal owing to a real inequality between the primitive angles.

There can be no question that a superficially sagittal condition may be attained in different ways, and one of the most interesting results at which we have arrived in the preparation of the present paper is that the so-called subdermal sagittal (pseudosagittal) spicules of the Heteropiidae have a quite different origin from the ordinary sagittal form, the basal ray not being homologous in the two cases.

With regard to Jenkin's [1908 B] supposed families Chiphoridae and Staurorrhaphidae, we have come to the conclusion that these are based upon purely imaginary distinctions. It will be remembered that Jenkin maintained that in these families a special type of spicule, the "chiactine," constitutes the first (or only) joint of the tubar skeleton. It seems highly improbable, from purely *a priori* reasons, that this joint should be differently constituted in different syconoid sponges. As a matter of fact, no one, so far as we are aware, has demonstrated how it arises in ordinary cases, such as *Sycon* or *Grantia*, but everybody has been content to speak of it as being composed of subgastral sagittal triradiates. It is, moreover, well known that these triradiates may develop an apical ray, as they do in many species (e. g. *Sycon ensiferum*, *Sycon verum* and *Grantia indica*), and thus become quadriradiates. Jenkin thought that he had demonstrated that in certain cases the subgastral quadriradiates arise by rotation and re-orientation of the basal rays of gastral quadriradiates, owing to the pressure of the developing chambers, and regarded this mode of origin as distinguishing his so-called chiactines from other subgastral tri- and quadriradiates. As, however, he made no attempt to show how the subgastral triradiates and quadriradiates arise in other cases, this distinction cannot be regarded as having any value; and we ourselves are of opinion, from our own observations, that the spicules which constitute the first joint of the tubar skeleton probably arise in the same way in all cases, although we are not disposed to accept without further evidence the exact mode of origin described by Jenkin.

It is certain that, in some cases at any rate, the spicules at the growing margin of the osculum have not yet assumed their definitive orientation, but exhibit a confused arrangement. Some of them gradually become oriented as dermal cortical spicules, with their three rays lying parallel to the surface, others as subgastral

spicules, with their basal rays centrifugally directed and their oral rays lying in the deeper part of the gastral cortex. The spicules of the other joints of the tubar skeleton, on the other hand, appear to arise in the walls of the chambers themselves, and this difference in mode of origin probably accounts for the difference which undoubtedly exists between them and the subgastral spicules.

We consider that the abolition of the families Chiphoridæ and Staurorrhaphidæ will effect a much needed simplification in the classification of the group, and also that it is highly desirable to do away with them from the point of view of practical convenience, for to draw a real distinction in practice between a so-called chiactine and an ordinary subgastral sagittal quadriradiate is quite impossible. The bending of the apical ray, whereby it is brought to lie nearly or quite in the same straight line as the basal ray, is merely a question of degree, as may be seen from the examination of the apical rays of ordinary gastral quadriradiates in various species.

The family Grantillidæ, proposed by one of us [Row, 1909] has, of course, also been abandoned by us. The rejection of Jenkin's chiact theory and the fact that we attach little importance to the mere presence of subdermal quadriradiates, have removed both the characters on which the family was founded, and it has consequently been merged in the Heteropiidæ.

The presence, however, of subgastral sagittal spicules (triradiates or quadriradiates) appears to be very characteristic of the Sycettid as contrasted with the Leucascid-Leucaltid line of descent.

The distribution of oxea in the Calcareous sponges presents an extremely difficult problem, as species possessing them occur side by side with species that lack them in almost all the large genera throughout the group. As a result we have found it impossible to assign to this character any such important place in our scheme of classification as previous authors have suggested, though as a matter of practical convenience we have used it as a basis for arranging the species of a genus in sections. Certainly the ability of some sponges to produce oxea may be looked upon as differentiating them, at any rate to some extent, from others which either have lost this power, although descended from oxea-bearing ancestors, or else have never possessed it.

Further, we have found that two types of oxeote spicules can be distinguished—the comparatively large, usually radially arranged form, and a much smaller for which we employ the term 'microxea.' In typical cases the latter are less than 0.1 mm. in length, and they are usually of a very definite hastate shape, with an enlargement at a short distance from the distal extremity. They thus form very characteristic and well-defined skeletal elements, and it is remarkable to find them recurring in so many perfectly distinct genera, belonging to most of the families within

the group. It would obviously be impossible, in any natural systematic arrangement, to associate together all the species which possess microxea, for these species differ amongst themselves in nearly every other respect. It is noteworthy that in some cases these spicules occur in very small numbers, so that they might easily be overlooked, while in others they are extremely numerous; and it seems by no means impossible that some individuals of a species may possess them while others do not. Nevertheless, as a matter of convenience, we have decided to make use of the presence or absence of these spicules for the purpose of distinguishing sections of genera.

In this connection, however, it must be observed that we do not include, in our conception of the term microxea, those long, hair-like spicules frequently found surrounding the osculum, or sometimes echinating the surface. These we believe to be merely slightly modified or imperfectly developed large oxea, and we include them under that head, under the term 'trichoxea.'

One is tempted to explain the sporadic distribution of oxea by speculations which, in the present state of our knowledge, are perhaps unjustifiable; but we may perhaps venture to suggest that the presence of oxea constituted a characteristic feature of some remote ancestor, and that the faculty of producing them has never been entirely lost, but requires special genetic conditions of which we know nothing before it can become active in any particular species. It is quite possible that our sections are somewhat artificial, but a grouping of the species by easily recognisable characters, especially in the larger genera, can hardly fail to be of use to the systematist.

Further discussion of the principles of classification may conveniently be left until we come to deal with the various subdivisions of the group.

#### SYSTEMATIC ARRANGEMENT OF THE CALCAREA.

##### Class and Order **CALCAREA.**

*Diagnosis.* Sponges in which the spicules are composed of carbonate of lime (calcite), and consist of either triradiate or quadriradiate systems, or are oxea (monaxons).

For many years past it has been the almost universal practice amongst spongologists to divide the class **CALCAREA** into two sharply contrasted orders, viz. **HOMOCÆLA**, in which the whole of the gastral cavity is lined by collared cells, and **HETEROCÆLA**, in which the collared cells are confined to special flagellate chambers, a practice which was first initiated by Poléjaeff in

1883. It appears to us that the time has come, owing to our greatly increased knowledge of the group, to abandon this primary division, and we now propose to consider the class as consisting of a single order only.

One reason for taking this step lies in the discovery of various intermediate forms. Such are the species of *Dendya*, which in the radial arrangement of the ascon tubes approach closely to the Leucascid type of HETEROCÆLA, and the species of *Leucascus* itself, which are but slightly modified from homocœl ancestors and form the starting-point of a distinct evolutionary series within the group HETEROCÆLA; while von Lendenfeld's *Homoderma sycandra* is obviously merely a *Sycon* in which the collared cells persist in the central gastral cavity throughout the life of the sponge.

Another even more important reason lies in the fact that, as noted above, the group HETEROCÆLA is at least diphyletic in origin, the genus *Dendya* and the family Sycettidæ forming two distinct starting points from which the evolution of the higher Leuconoid forms has proceeded.

We therefore propose to divide the class CALCAREA straightway into families, of which the first will be the Homocœlidæ, practically co-extensive with the HOMOCÆLA of Poléjaeff. His group HETEROCÆLA, on the other hand, is here definitely abandoned, being represented by the families Leucascidæ, Leucaltidæ, Minchinellidæ, Murrayonidæ, Sycettidæ, Heteropiidæ, Grantiidæ, Amphoriscidæ and Lelapiidæ.

#### Family 1. HOMOCÆLIDÆ nov.

*Diagnosis.* The whole of the gastral cavity and its various outgrowths lined by collared cells throughout the life of the sponge. Sponge colony rarely radiate, and, if so, the central individual retains the primitive ascon structure, with a lining of collared cells and without a special gastral cortex. No true dermal membrane or true dermal cortex is ever developed.

In 1872 Haeckel proposed seven genera of "Ascon" Calcarea, based upon the permutations and combinations of triradiate, quadriradiate, and oxeote spicules. This constituted his so-called "natural" system, but he also had an "artificial" system based upon the type of colony formation. Both systems have shown themselves far from satisfactory in practice and have long since been abandoned.

In 1883 Poléjaeff, recognising the extreme difficulty of subdividing the group, placed the whole of the species in the genus *Leucosolenia* of Bowerbank, which takes priority over all Haeckel's genera and is the only genus recognised by Poléjaeff in his order HOMOCÆLA.

In 1891 von Lendenfeld proposed a modification of Haeckel's "natural" system, retaining only two genera, *Ascetta* and *Ascandra*, the former genus lacking oxea, the latter possessing them.

In the same year Dendy, in his "Monograph of the Victorian Calcareous Homocœla," while accepting Poléjaeff's conclusion that only a single genus could be recognised, proposed to divide that genus into sections and subsections, according to the type of colony formation and canal system. Three sections were recognised, *Simplicia*, *Reticulata* and *Radiata*, and the *Reticulata* were further subdivided into *Indivisa* and *Subdivisa*, according to the absence or presence of an endogastric network. Of these sections the *Radiata* now constitute the genus *Dendya* of Bidder, while the other two are of little value to the systematist.

In 1896 Minchin proposed to distinguish three genera of HOMOCÆLA, *Clathrina*, *Leucosolenia* and *Ascandra*, and in 1900, in Lankester's 'Text-Book of Zoology,' he recognised two distinct families, Clathrinidæ and Leucosoleniidæ, and gave (p. 110) the following classification and diagnosis:—

"GRADE A. HOMOCÆLA, Pol., s. Ascones, H.

"Gastral layer continuous.

"FAMILY 1. CLATHRINIDÆ, Minchin. Form reticulate. Triradiate systems always present, equiangular; monaxons present or absent. Collar-cells with nucleus at base. Larva a parenchymula. Genera—*Clathrina*, Gray (= *Ascetta*, H., pars, *Ascallis*, H., pars, etc., and *Leucascus*, D.); Figs. 2, 6, 7, 8; *Ascandra*, H., emend. (= *Homandra*, Ldf., for *Ascandra falcata*, H.); *Dendya*, Bidder, for *Clathrina tripodifera*, Crtr. FAMILY 2. LEUCOSOLENIDÆ, Minchin. Form erect; monaxons always present; triradiates, if present, alate; collar-cells with nucleus apical; larva an amphiblastula. Genera—*Ascyssa*, H.; *Leucosolenia*, Bwk. (= *Ascandra*, H., pars, etc.); Figs. 3, 4, 5."

In 1909, Zool. Anzeiger, xxxv. p. 230, in response to criticisms by Hammer [1908] and Dendy as to the position of the nucleus in the collared cells, he emended his diagnoses as follows:—

"Class CALCAREA. Sponges with the skeleton composed of calcite, in the form of spicules either monaxon, triradiate or quadriradiate in form.

"Grade 1. HOMOCÆLA. Calcareous with the gastral layer of collar-cells continuous, not forming separate flagellated chambers.

"Family 1. CLATHRINIDÆ. Oscular tubes generally short, arising as shallow vents from the network of tubes, form of the body typically reticulate. Triradiate spicules always present, equiangular, and with the crystalline optic axis vertical to the facial plane of the rays; monaxon spicules present or absent. Collar-cells with the flagellum arising quite independently of the

nucleus, which is spherical in form, and situated at the base of the cell. Larva a parenchymula.

"Family 2. LEUCOSOLENIIDÆ. Oscular tubes long, arising as distinct individuals from the stolon-like system of basal tubes; form of the body erect. Monaxon spicules always present; triradiates, if present, typically bilateral in form, with two paired, and one unpaired angles, and with the crystalline optic axis never vertical, but always inclined, to the facial plane of the rays. Collar-cells with the flagellum arising directly from the pear-shaped nucleus, which is situated at, or near, the apex of the cell. Larva an amphiblastula."

Without entering into a long discussion as to the theoretical value of these diagnoses, we may point out that in some respects they are in actual practice very difficult of application. Only very few of the numerous described species of homocœl sponges have been examined with reference to the mode of origin of the flagellum in the collared cells, the nature of the larva, or the direction of the crystalline optic axis in relation to the facial plane of the spicule. If it were necessary to investigate these very obscure characters in every case, the classification of the group would indeed make slow progress.

The more obvious characters which Professor Minchin first made use of for the subdivision of the group, viz., the equiangular or alate character of the triradiates and the position of the nucleus of the collared cell, together with the erect or reticulate form of the colony, lose their value when we extend our investigations beyond the familiar British species. The Australian species, *Leucosolenia lucasi*, *L. stolonifer* and *Ascute uteoides* all have the characteristic non-reticulate, "*Leucosolenia*" form, and all possess oxea (monaxons); *L. stolonifer* and *A. uteoides*, however, have collared cells with basally placed nuclei, while in *L. lucasi* the nuclei are apical, though unfortunately the position of the basal granule is—as is always the case in specimens preserved without very special precautions—indeterminable. In *L. stolonifer* and *L. lucasi*, again, some at any rate of the triradiates are apparently equiangular and indistinguishable from clathrinid spicules. The test concerning the direction of the optic axis is far too difficult to apply accurately to be of any general value.

As to the larvæ, again, not only are these rarely met with in the Homocœlidæ, but Professor Minchin himself has shown that there is a transition from the one type of larva (parenchymula) to the other type (amphiblastula). He says (Lankester's 'Text-Book of Zoology,' part ii. p. 75), "The type of parenchymula larva exemplified by *Clathrina reticulum* (Fig. 59, 1), affords an easy transition to the so-called amphiblastula found in *Leucosoleniidae*, and in the great majority of the HETEROCÆLA."

The genus *Clathrina* of Gray [1867] was originally based on the reticulate form of the sponge colony, and this is still almost the only character which could be made use of in practice as a

distinction from *Leucosolenia*, but here again we know that no sharp separation can be drawn between the two types of external form, for one and the same colony may be reticulate in its lower, and non-reticulate in its upper portion.

In short, we do not think that any spongologist who has examined a large and representative collection of Homocœlidæ would be prepared to maintain Professor Minchin's subdivision of the group into Clathrinidæ and Leucosoleniidæ. It appears to us that the most that can be done at present is to pick out and diagnose in a more or less satisfactory way certain more or less isolated and well-characterised generic forms, and to leave the vast bulk of the species in the genus *Leucosolenia*.

At the same time we are of opinion, as already pointed out in the introduction, that Professor Minchin has indicated some characters at any rate which will in the future prove to be of very great value for taxonomic purposes, and we ourselves have made extensive use of the position of the nucleus in the collared cells, as roughly determined from the spirit material, in support of our views as to the evolution of the heterocœl Calcarea. The reason why this character appears to be of less value amongst the Homocœlidæ will be discussed in the section dealing with the phylogeny of the group.

There can be no doubt that the Homocœlidæ have all been derived from a common *Olynthus*-like ancestor, from which a number of lines of descent have branched out in various directions. Colony formation seems to have played the chief part in the process of evolution and many different types of colony have thus arisen.

At present we are only able to distinguish four genera in this family, *Leucosolenia*, *Ascute*, *Ascyssa* and *Dendya*. Three of these, *Ascute*, *Ascyssa* and *Dendya*, are easily and clearly definable, possessing well-marked characters, but the remaining genus, *Leucosolenia*, is distinguished almost entirely by negative characters, and contains a very large number of species, presenting a very great diversity amongst themselves, both in colony-form and spiculation.

#### Genus I. LEUCOSOLENIA Bowerbank [1864-1882].

*Diagnosis.* Diverticula of the gastral cavity, if any, never radially arranged around a central tube. Skeleton composed of tri-radiate or quadriradiate spicules, to which oxea may be added. No uteoid dermal skeleton. Nucleus of collared cells basal or apical.

For illustrations of this genus see Dendy [1891 A].

The external form in species of this genus ranges from simple *Olynthus*-like individuals, which may be connected together by a

basal stolon as in *L. lucasi* and *L. stolonifer*, to complex reticulate colonies which have acquired by integration a new individuality of a higher type, sometimes with pseudogaster, pseudosculum, pseudoderm and pseudopores, as in *L. ventricosa*, and sometimes with reversal of the canal system as in *L. cavata*. It may happen that one and the same colony exhibits a reticulate structure in one portion, and a non-reticulate in another, as in several forms figured by Haeckel [1872]. For further information as to the variations in the mode of colony formation the reader is referred to Dendy [1891A].

Haeckel's *Ascandra falcata*, which we include in the genus *Leucosolenia*, has been made by both Minchin [1896] and von Lendenfeld [1891] the type of a special genus (with the generic names of *Ascandra* and *Homandra* respectively) on account of the peculiar appearance of the gastral layer, which is thrown into folds in such a way that in transverse section there appear to be present a series of shallow radial tubes. These endodermal ridges are always supported by the large apical rays of the gastral quadriradiates, which have either pushed the layer of collared cells out before them as they grow, or formed a foundation upon which the collared cells have spread. It may be pointed out that other Homocelidæ also show this type of structure, e. g. *L. canariensis* and *L. gegenbauri*. We ourselves do not consider that this character is of sufficient importance, *per se*, to take generic rank; nor do we consider that there is any relationship between the "pseudoradial" character thus given to the gastral layer, and a true syconoid canal system, since, in the radial tubes of *Sycon*, for example, both dermal and gastral layers are folded, while in *Leucosolenia falcata* the gastral layer only is affected. Further, embryology shows that the radial tubes of *Sycon* are outgrowths from the central gastral cavity, and not formed by ingrowths into it. Had the syconoid type of canal system originated from some such condition as that of *Leucosolenia (Ascandra) falcata*, the sycon person would have been provided with a dermal cortex *ab initio*, whereas the more primitive Sycettidæ have the ends of the chambers freely projecting on the surface of the sponge.

The position of the nucleus of the collared cells in this genus is not, so far as we are aware, correlated with any particular type of spiculation or canal system, and we cannot, if only for practical reasons, make use of this character by itself for subdividing the genus. As a means of grouping the various species of the genus into sections, however, we may, as in the higher forms, adopt the criterion afforded by the presence or absence of oxea.

We recognise the following species as belonging to this genus:—

#### SECTION A. Oxea present.

##### 1. *L. AMCEBOIDES* Haeckel.

*Ascandra complicata*, var. *amœboides* Haeckel [1872].



2. L. ANGULATA von Lendenfeld.  
*Ascandra angulata* von Lendenfeld [1891].
3. L. ARACHNOIDES Haeckel.  
*Ascandra variabilis* var. *arachnoides* Haeckel [1872].
4. L. ARMATA Haeckel.  
*Olynthus pocillum* Haeckel [1870], *fide* Haeckel [1872].  
*Asculmis armata* Haeckel [1872].  
 The earlier name is a *nomen nudum*.
5. L. ATLANTICA Thacker.  
*Leucosolenia atlantica* Thacker [1908].
6. L. BELLA Row.  
*Leucosolenia bella* Row [1913 MS.].
7. L. BOTRYOIDES (Ellis and Solander). Type species of the genus.  
*Spongia botryoides* Ellis and Solander [1786].  
*Leucosolenia botryoides* Minchin [1905].
8. L. BOTRYS Haeckel.  
*Ascandra botrys* Haeckel [1872].
9. L. CERVICORNIS Haeckel.  
*Ascandra variabilis* var. *cervicornis* Haeckel [1872].
10. L. CLARKII Verrill.  
*Ascartis clarkii* Verrill [1873].
11. L. COMPLICATA Montagu.  
*Spongia complicata* Montagu [1812].  
*Grantia botryoides* Lieberkühn [1859], *fide* Haeckel [1872].  
*Olynthus hispidus* Haeckel [1859], *fide* Haeckel [1872].  
*Leucosolenia complicata* Minchin [1905].
12. L. CONFERVICOLA Haeckel.  
*Ascandra variabilis* var. *confervicola* Haeckel [1872].
13. L. CONTORTA Bowerbank.  
*Leucosolenia contorta* Bowerbank [1864-1882].  
*Ascandra contorta* Haeckel [1872].
14. L. CORALLORHIZA Haeckel.  
*Sycorhiza corallorhiza* Haeckel [1870].  
*Auloplegma haeckeli* O. Schmidt MS., *fide* Haeckel [1872].  
*Ascartis corallorhiza* Haeckel [1872].
15. L. CORDATA Haeckel.  
*Ascandra cordata* Haeckel [1872].
16. L. Densa Haeckel.  
*Tarrus densus* Haeckel [1870].  
*Nardopsis gracilis* Haeckel [1870], *fide* Haeckel [1872].  
*Ascandra densa* Haeckel [1872].

17. L. DISCOVERYI *Jenkin*.  
*Leucosolenia discoveryi* Jenkin [1908].
18. L. DUBIA *Dendy*.  
*Leucosolenia dubia* Dendy [1891 A].
19. L. ECHINATA *Kirk*.  
*Leucosolenia echinata* Kirk [1893].
20. L. ECHINOIDES *Haeckel*.  
*Leucosolenia echinoides* Haeckel [1870].  
*Olynthus cyathus* Haeckel [1870], *fide* Haeckel [1872].  
*Ascandra echinoides* Haeckel [1872].
21. L. ELEANOR *Urban*.  
*Leucosolenia eleanor* Urban [1905].
22. L. FABRICII *O. Schmidt*.  
*Leucosolenia fabricii* O. Schmidt [1870].
23. L. FALCATA *Haeckel*.  
*Ascandra falcata* Haeckel [1872].
24. L. FRAGILIS *Haeckel*.  
*Ascortis fragilis* Haeckel [1872].  
*Leucosolenia botryoides* James-Clark [1869], *fide* Haeckel [1872].  
*Leucosolenia thamnoides* Haeckel [1870], *fide* Haeckel [1872].  
Haeckel's earlier name is a *nomen nudum*.
25. L. HERMESI *Breitfuss*.  
*Ascandra hermesi* Breitfuss [1896 B].
26. L. HISPIDISSIMA *Haeckel*.  
*Ascandra variabilis* var. *hispidissima* Haeckel [1872].
27. L. HORRIDA *Haeckel*.  
*Nardopsis horrida* O. Schmidt MS., *fide* Haeckel [1872].  
*Ascortis horrida* Haeckel [1872].
28. L. INCERTA *Urban*.  
*Leucosolenia incerta* Urban [1908].
29. L. IRREGULARIS *Jenkin*.  
*Leucosolenia irregularis* Jenkin [1908 A].
30. L. LACUNOSA *Johnston*.  
*Grantia lacunosa* Bean MS., *fide* Johnston [1842].  
*Grantia lacunosa* Johnston [1842].  
*Ascortis lacunosa* Haeckel [1872].
31. L. LAXA *Kirk*.  
*Leucosolenia laxa* Kirk [1895].

32. L. LIEBERKÜHNII *O. Schmidt*.  
*Grantia botryoides* Lieberkühn [1859], *vide* O. Schmidt [1862], and Haeckel [1872].  
*Grantia lieberkühnii* O. Schmidt [1862].  
*Leucosolenia robusta* Haeckel [1870], *vide* Haeckel [1872].  
*Ascandra lieberkühnii* Haeckel [1872].
33. L. LUCASI *Dendy*.  
*Leucosolenia lucasi* Dendy [1891 A].
34. L. MINCHINI *Jenkin*.  
*Leucosolenia minchini* Jenkin [1908 B].
35. L. NITIDA *Haeckel*.  
*Olynthium nitidum* Haeckel [1870].  
*Olynthium splendidum* Haeckel [1870], *vide* Haeckel [1872].  
*Ascandra nitida* Haeckel [1872].
36. L. PANIS *Haeckel*.  
*Ascandra panis* Haeckel [1872].
37. L. PINUS *Haeckel*.  
*Leucosolenia botryoides* Lacaze-Duthiers MS., *vide* Haeckel [1872].  
*Ascandra pinus* Haeckel [1872].
38. L. RETICULATA *Haeckel*.  
*Tarrus reticulatus* Haeckel [1870].  
*Ascandra reticulum*, var. *reticulata* Haeckel [1872].
39. L. RETICULUM *O. Schmidt*.  
*Nardoa reticulum* O. Schmidt [1862].  
*Ascandra reticulum* Haeckel [1872].
40. L. SERTULARIA *Haeckel*.  
*Ascandra sertularia* Haeckel [1872].
41. L. STOLONIFER *Dendy*.  
*Leucosolenia stolonifer* Dendy [1891 A].
42. L. TENUPILOSA *Dendy*.  
*Leucosolenia tenuipilosa* Dendy [1905].  
*Leucosolenia canariensis* Thacker [1908], pars, *vide* Row [1909].
43. L. TENUIS *Schuffner*.  
*Ascandra tenuis* Schuffner [1877].
44. L. VARIABILIS *Haeckel*.  
*Leucosolenia variabilis* Haeckel [1870].  
*Ascandra variabilis* Haeckel [1872].  
*Leuconia somei* Bowerbank [1864-1882], *vide* Minchin [1896].  
*Leucosolenia variabilis* Minchin [1905].

45. L. VENTRICOSA *Carter*.*Clathrina ventricosa* Carter [1885-1886].*Leucosolenia ventricosa* Dendy [1891 A].

## SECTION B. Without oxea.

46. L. AGASSIZII *Haeckel*.*Asclittis lamareckii* var. *agassizii* Haeckel [1872].47. L. BLANCA *Michlucho-Maclay*.*Guancha blanca* Michlucho-Maclay [1868].*Olythkus* (dc.) *guancha* Haeckel [1870], *fide* Haeckel [1872].*Ascetta blanca* Haeckel [1872].48. L. CANARIENSIS *Michlucho-Maclay*.*Nardoa canariensis* Michlucho-Maclay [1868].*Nardoa sulphurea* Michlucho-Maclay [1868], *fide* Haeckel [1872].*Nardoa rubra* Michlucho-Maclay [1868], *fide* Haeckel [1872].*Asclittis canariensis* Haeckel [1872].*Leucosolenia nansenii* Breitung [1896], *fide* Thacker [1908].*Asclittis compacta* Schuffner [1877], *fide* Thacker [1908].*Leucosolenia canariensis* Thacker [1908].49. L. CANCELLATA *Verrill*.*Leucosolenia cancellata* Verrill [1873].50. L. CAROLI *Haeckel*.*Asclittis darwinii*, var. *caroli* Haeckel [1872].51. L. CAVATA *Carter*.*Clathrina cavata* Carter [1885-1886].*Leucosolenia cavata* Dendy [1891 A].52. L. CEREBRUM *Haeckel*.*Asclittis cerebrum* Haeckel [1872].53. L. CHALLENGERI *Poléjaeff*.*Leucosolenia challengerii* Poléjaeff [1883].54. L. CHARYBDÆA *Haeckel*.*Asclittis gegenbauri* var. *charybdeæ* Haeckel [1872].55. L. CLATHRATA *Carter*.*Leucetta clathrata* Carter [1883].*Clathrina tripodifera* var. *gravidæ* Carter [1885-1886], *fide* Row [1913 MS.].*Grantia cliffoni* Bowerbank MS., *fide* Row [1913 MS.].*Leucosolenia intermedia* Kirk [1895], *fide* Row [1913 MS.].*Leucosolenia clathrata* Row [1913 MS.].

56. L. CLATHRUS *O. Schmidt*.  
*Grantia clathrus* *O. Schmidt* [1862].  
 ? *Clathrina sulphurea* *J. E. Gray* [1867], *fide* *Haeckel* [1872].  
*Tarrus labyrinthus* *Haeckel* [1870], *fide* *Haeckel* [1872].  
*Nardoa labyrinthus* *O. Schmidt* MS., *fide* *Haeckel* [1872].  
*Ascetta clathrus* *Haeckel* [1872].
57. L. CONVALLARIA *Haeckel*.  
*Ascilla gracilis* var. *convallaria* *Haeckel* [1872].
58. L. CORIACEA *Montagu*.  
*Spongia coriacea* *Montagu* [1812].  
*Grantia multicauda* *Bean* MS., *fide* *Johnston* [1842].  
*Clathrina sulphurea* *Carter* [1871 A], *fide* *Haeckel* [1872].  
*Ascetta coriacea* *Haeckel* [1872].
59. L. DARWINII *Haeckel*.  
*Leucosolenia darwinii* *Haeckel* [1870].  
*Asclatis darwinii* *Haeckel* [1872].
60. L. DECIPIENS *Haeckel*.  
*Asclatis cerebrum* var. *decipiens* *Haeckel* [1872].
61. L. DEPRESSA *Dendy*.  
*Leucosolenia depressa* *Dendy* [1891 A].
62. L. DICTYOIDES *Haeckel*.  
*Leucosolenia dictyoides* *Haeckel* [1870].  
*Ascetta primordialis* var. *dictyoides* *Haeckel* [1872].
63. L. FALKLANDICA *Breitfuss*.  
*Leucosolenia falklandica* *Breitfuss* [1898 E].
64. L. FLEXILIS *Haeckel*.  
*Ascetta flexilis* *Haeckel* [1872].
65. L. GARDINERI *Dendy*.  
*Leucosolenia gardineri* *Dendy* [1913].
66. L. GEGENBAURI *Haeckel*.  
*Leucosolenia gegenbauri* *Haeckel* [1870].  
 ? *Nardoa spongiosa* *Kölliker* [1864], *fide* *Haeckel* [1872].  
*Asclatis gegenbauri* *Haeckel* [1872].
67. L. GOETHEI *Haeckel*.  
*Leucosolenia goethei* *Haeckel* [1870].  
*Asclatis goethei* *Haeckel* [1872].
68. L. GRACILIS *Haeckel*.  
*Ascilla gracilis* *Haeckel* [1872].
69. L. GRANTII *Haeckel*.  
*Leucosolenia grantii* *Haeckel* [1870].  
*Asclatis solanderii* (= *Asclatis botryoides* var. *solanderii*)  
*Haeckel* [1872], *fide* *Haeckel* [1872].

70. L. HIMANTIA *Johnston*.  
*Grantia botryoides* var. *himantia* Johnston [1842].  
*Ascetta coriacea* var. *himantia* Haeckel [1872].
71. L. JAPONICA *Haeckel*.  
*Ascilla japonica* Haeckel [1872].
72. L. LAMARCKII *Haeckel*.  
*Leucosolenia lamarckii* Haeckel [1870].  
*Aulorhiza intestinalis* Haeckel [1870], *fide* Haeckel [1872].  
*Ascallis lamarckii* Haeckel [1872].
73. L. LOCULOSA *Haeckel*.  
*Ascetta primordialis* var. *loculosa* Haeckel [1872].
74. L. MACLEAYI von Lendenfeld.  
*Ascetta macleayi* von Lendenfeld [1885 A].
75. L. MINORICENSIS *Lackschewitsch*.  
*Leucosolenia minoricensis* Lackschewitsch [1886].
76. L. MULTIFORMIS *Breitfuss*.  
*Leucosolenia multiformis* Breitfuss [1898 B].
77. L. OSCULUM *Carter*.  
*Clathrina osculum* Carter [1885-1886].
78. L. PEDUNCULATA von Lendenfeld.  
*Leucopsis pedunculata* von Lendenfeld [1885 B].
79. L. PELLICULATA *Dendy*.  
*Leucosolenia pelliculata* Dendy [1891 A].
80. L. PHILIPPINA *Haeckel*.  
*Ascetta blanca* var. *phillipina* Haeckel [1872].
81. L. POTERIUM *Haeckel*.  
*Ascetta primordialis* var. *poterium* Haeckel [1872].  
*Ascandra conulata* von Lendenfeld MS., *fide* Breitfuss [1897].
82. L. PRIMORDIALIS *Haeckel*.  
*Proscyum primordiale* Haeckel [1870].  
*Olynthus simplex* Haeckel [1870], *fide* Haeckel [1872].  
? *Grantia pulchra* O. Schmidt [1862], *fide* Haeckel [1872].  
*Nardoa arabica* Michlucho-Maclay MS., *fide* Haeckel [1872].  
*Ascetta primordialis* Haeckel [1872].
83. L. PROTOGENES *Haeckel*.  
*Ascetta primordialis* var. *protogenes* Haeckel [1872].  
*Ascetta procumbens* von Lendenfeld [1885 B], *fide* Dendy [1891 A].

84. L. PROXIMA Dendy.  
*Leucosolenia proxima* Dendy [1891 A].
85. L. PSAMMOPHILA Row.  
*Leucosolenia psammophila* Row [1913 MS.].
86. L. PULCHERRIMA Dendy.  
*Leucosolenia pulcherrima* Dendy [1891 A].
87. L. ROSEA Kirk.  
*Leucosolenia rosea* Kirk [1895].
88. L. SAGITTARIA Haeckel.  
*Ascetta sagittaria* Haeckel [1872].
89. L. SCEPTRUM Haeckel.  
*Ascetta sceptrum* Haeckel [1872].
90. L. SPINOSA von Lendenfeld.  
*Ascetta spinosa* von Lendenfeld [1891].
91. L. STIPITATA Dendy.  
*Leucosolenia stipitata* Dendy [1891 A].
92. L. VESICULA Haeckel.  
*Ascetta vesicula* Haeckel [1872].
93. L. VITREA Row.  
*Leucosolenia vitrea* Row [1913 MS.].
94. L. WILSONI Dendy.  
*Leucosolenia wilsoni* Dendy [1891 A].

The following species are of doubtful value :—

95. L. LAMINOCLATHRATA Carter.  
*Clathrina laminoclathrata* Carter [1885–1886].  
Too imperfectly described to be recognisable.
96. L. PULCHRA O. Schmidt.  
*Grantia pulchra* O. Schmidt [1865].  
Possibly identical with *L. primordialis* Haeckel, *fide* Haeckel [1872].
97. L. SPONGIOSA Kölliker.  
*Nardoa spongiosa* Kölliker [1864].  
Possibly identical with *L. gegenbauri* Haeckel, *fide* Haeckel [1872].
98. L. SULPHUREA Gray.  
*Clathrina sulphurea* J. E. Gray (non Carter) [1867].  
Possibly identical with *L. clathrus* O. Schmidt, *fide* Haeckel [1872].

## Genus 2. DENDYA Bidder [1898].

*Diagnosis.* Sponge colony consisting of a large central individual lined by collared cells, from which radially arranged diverticula are given off. Skeleton composed of equiangular triradiates to which quadriradiates may be added. Subgastral sagittal radiates never present. Nuclei of collared cells probably always basal.

For illustrations of this genus see Dendy [1891 A].

Carter's *Clathrina tripodifera* was included by Dendy [1891 A] in the genus *Leucosolenia*, as the sole representative of the "Radiate" section of that genus. Bidder [1898] proposed for its reception a new genus, *Dendya*, and the recent discovery by the 'Sealark' Expedition of a closely allied, but quite distinct, species in the Indian Ocean seems to justify the retention of Bidder's genus. Unfortunately Bidder associated his genus with Poléjaeff's *Heteropegma* (= *Leucaltis*) in a new family Heteropegmidae, of which *Dendya* was made the type genus. While admitting a certain degree of relationship between *Dendya* and *Leucaltis*, we cannot agree that this is so close as to justify placing them in the same family, for not only is *Leucaltis* corticate, while *Dendya* is non-corticate, but *Leucaltis* is also heterocœl, while *Dendya* is homocœl.

The chief interest attaching to the genus *Dendya* lies in its radiate structure, which, at first sight, seems to suggest a possible starting point for the Sycettid as well as for the Leucascid-Leucaltid line of descent. We no longer consider, however, that *Dendya* stands very near the origin of the Sycettidae, from the simplest of which it differs widely in the structure of the skeleton, especially in the absence of subgastral sagittal radiates, in the fact that the radial tubes tend to anastomose, and in the basal position of the nuclei of the collared cells. The tendency of the radial tubes to form reticulations is indeed a difficulty in the way of separating the genus sharply from *Leucosolenia*, a fact well illustrated by Carter's *Leucetia clathrata* (= *Leucosolenia clathrata*), which is intermediate between the two as regards the canal system while resembling *Dendya* in the presence of the characteristic dermal tripod spicules. [Row, 1913 MS.]

We recognise the following species as belonging to this genus:—

1. D. PROLIFERA *Dendy*.  
*Dendya prolifera* Dendy [1913].
2. D. TRIPODIFERA *Carter*. Type species of the genus.  
*Clathrina tripodifera* Carter [1885-1886].  
*Leucosolenia tripodifera* Dendy [1891 A].  
*Dendya tripodifera* Bidder [1898].



## Genus 3. ASCUTE nov.

*Diagnosis.* The diverticula of the gastral cavity, if any, never radially arranged around a central tube. With a uteoid dermal skeleton of colossal longitudinal oxea. Nuclei of the collared cells (? always) basal.

As the presence of a uteoid dermal skeleton is considered to form a good generic character in other families, we see no reason why it should not be used in the same way amongst the Homocœlidæ, and therefore propose this genus for Dendy's *Leucosolenia uteoides*, with which Carter's *Aphroceras asconoides* is doubtless to be associated. The nucleus of the collared cells is basal in the former species, but its position is not known in the latter.

In both the known species of this genus the sponge has the form of a group of simple ascon persons, attached to one another by their bases, and without any anastomoses in the colony.

We recognise the following species as belonging to this genus:—

1. A. ASCONOIDES *Carter*.  
*Aphroceras asconoides* Carter [1885–1886].
2. A. UTEOIDES *Dendy*. Type species of the genus.  
*Leucosolenia uteoides* Dendy [1892 C].

## Genus 4. ASCYSSA Haeckel [1872].

*Diagnosis.* Diverticula of the gastral cavity, if any, never radially arranged around a central tube. Skeleton consisting entirely of oxea.

For illustrations of this genus see Haeckel [1872].

We consider the entire absence of radiate spicules as affording sufficient reason for the generic separation of Haeckel's two species of *Ascyssa* from all the other Homocœlidæ.

We assign the following species to this genus:—

1. A. ACUFERA *Haeckel*.  
*Ascyssa acufera* Haeckel [1872].
2. A. TROGLODYTES *Haeckel*. Type species of the genus.  
*Ascyssa troglodytes* Haeckel [1872].

## Family 2. LEUCASCIDÆ Dendy [1892 B] (emend.).

*Diagnosis.* Sponge typically forming a massive colony, usually with several or many oscula, but sometimes integrated into a single individual with definite external form. Without any large central gastral cavity lined by collared cells, but with an exhalant canal system devoid of collared cells.

Flagellate chambers ranging from long and possibly branched, with a tendency to radial arrangement round the exhalant canals, to small, approximately spherical, and scattered. With a distinct and independent dermal membrane (or cortex) pierced by true dermal pores. Skeleton consisting mainly of equiangular and equiradiate spicules, which may become sagittal at the oscular margins. Radiates of the chamber layer without definite arrangement, but irregularly scattered in the walls of the elongated chambers, or between the small, scattered chambers. No subgastral sagittal radiates. Nuclei of collared cells probably always basal.

This family was provided by Dendy [1892 B] for the reception of the genus *Leucascus* with its two species, *L. simplex* and *L. clavatus*. Minchin [1900] refused to recognise either the genus or the family, and included the two species in his *Clathrina*, apparently ignoring the fact that none of the known species of *Clathrina*, or indeed any other homocœl sponge, possess an independent dermal membrane or cortex. It is true that many *Clathrinas* develop a pseudoderm, but this is invariably formed from the outermost tubes of the reticulation, and therefore includes a layer of endoderm (gastral layer). In *Leucascus*, on the other hand, the dermal membrane is formed exclusively of ectoderm and mesogloea (dermal layer), and does not consist merely of the outer tubes of the reticulation. Moreover, the radiate and non-reticulate arrangement of the elongated chambers in *Leucascus* indicates a relationship with *Dendya* rather than with the *Clathrinoid* *Leucosolenias*.

We here extend our conception of the family Leucascidæ to include, not only the genus *Leucascus* and allied genera with a similar type of canal system, but also a number of species with a leuconoid type of canal system, which we have hitherto assigned to the genera *Leucandra* and *Leucilla*. The skeleton of these species, in the absence of all traces of syconoid ancestry such as subgastral sagittal triradiates, clearly indicates a wide phylogenetic separation from the typical *Leucandras* and *Leucillas*, such as *Leucandra aspera* and *Leucilla amphora*, and closely resembles that of *Leucascus*.

It will be remembered that Haeckel, in "Die Kalkschwämme" (vol. ii. p. 122, [1872]), placed his *Leucetta primigenia* (one of the species which was formerly assigned to *Leucandra*, but now placed in the Leucascidæ) at the beginning of his Leucones, which he derived directly from an *Ascon* ancestry. He says: "*Leucetta primigenia*, als die wahrscheinliche Stammform der Leuconen, steht in ihre Skelettbildung der gemeinsamen Stammform aller Kalkschwämme, der *Ascetta primordialis*, so nahe, dass man sie unmittelbar von der letzteren ableiten kann." We agree with these views so far as the relationship to the "Ascones" is concerned, but we can no longer agree that the more advanced types of "Leucones" (such as *Leucandra*) have had a leucettid ancestry.

There is certainly no indication whatever of the genus *Leucetta* having passed through a syconoid stage in its evolution, as we believe to be the case with the true *Leucandras* and *Leucillas*, and we therefore propose to re-establish this genus for certain leuconoid *Leucascidæ*.

We have also placed in this family the genus *Pericharax* Poléjaeff [1883], on account of the similarity of the skeleton and the basal position of the nucleus in the collared cells, while the genus *Leucomalthe* can only be placed here provisionally.

It should perhaps be mentioned here that von Lendenfeld's genus *Leucopsis* [1885 B] was also supposed by its author to represent a "Transition form between *Asconidæ* and *Leuconidæ*." The genus, with its single species, *Leucopsis pedunculata*, was, however, so imperfectly described that it is impossible to form any definite opinion as to its systematic position; it is very possibly merely a reticulate *Leucosolenia* with well developed mesogleæ and pseudogaster, an opinion which is supported by an examination of some of von Lendenfeld's type specimens, which one of us was able to make in Berlin. At all events, it appears to differ widely from any of our *Leucascidæ*, and it has been placed by us among the *Leucosolenias*.

We have been able to determine the position of the nucleus in no less than ten species of this small family, including five species of *Leucetta*, and in all cases have found it basal, a fact that affords strong support to our view that the genus *Leucetta* should be very widely separated from *Leucandra*, in which the nucleus is, so far as we are aware, always apical.

#### Genus 5. LEUCASCUS Dendy [1892 B].

*Diagnosis.* Flagellate chambers greatly elongated, tubular, and sometimes copiously branched.

For illustrations of this genus see Dendy [1893 A].

We recognise the following species in this genus:—

##### SECTION A. Without oxea.

##### 1. *L. INSIGNIS* Row.

*Leucascus insignis* Row [1913 MS.].

##### 2. *L. SIMPLEX* Dendy. Type species of the genus.

*Leucascus simplex* Dendy [1892 B].

##### SECTION B. With large radially arranged oxea.

##### 3. *L. CLAVATUS* Dendy.

*Leucascus clavatus* Dendy [1892 B].

Genus 6. *LEUCOMALTHE*, Haeckel [1872] (emend.).

*Diagnosis.* Colony individualised, with definite external form and large central gastral cavity opening by a large single osculum. Flagellate chambers greatly elongated, tubular, copiously branched. Skeleton consisting of regular radiates, large longitudinally placed oxea scattered throughout the sponge body and not confined to the cortex, and minute, irregularly hastate microxea.

For illustrations of this genus see Haeckel [1872].

The name *Leucomalthe*, originally applied to one of Haeckel's subgenera, is retained for his *Leucandra bomba*, which presents many peculiarities distinguishing it from the rest of the species of that genus. Of these, the most important from the point of view of our present classification is the very unusual type of canal system figured by Haeckel, which shows a number of large and very much branched flagellate chambers radiating from a central gastral cavity. This is very different from the normal leuconoid canal system, and is fairly similar to that of *Leucascus*. On this account, and on account of the regular triradiates of the skeleton, we have placed this species among the Leucascidae, though, it must be acknowledged, on somewhat doubtful grounds, and the peculiarities of its spiculation have necessitated the provision of a special genus to receive it.

The only known species is :—

1. *L. BOMBA* Haeckel.

*Leucandra bomba* Haeckel [1872].

Genus 7. *LEUCETTA* Haeckel [1872] (emend.).

non *Leucetta* Poléjaeff [1883].

non *Leucetta* von Lendenfeld [1891].

- *Diagnosis.* Canal system leuconoid, with small, spherical or sub-spherical flagellate chambers irregularly scattered through the chamber layer.

For illustrations of this genus see Haeckel [1872] and Dendy [1913].

Haeckel [1872] proposed the genus *Leucetta* for calcareous sponges with a leuconoid canal system and a skeleton composed of triradiate spicules only, taking *L. primigenia* for his type species.

Poléjaeff [1883] abandoned Haeckel's classification, but retained the name *Leucetta* in an entirely different sense, equivalent to our *Leucetusa*, taking one of Haeckel's species, *L. corticata*, for the type species of his genus.

Von Lendenfeld [1891] used the genus *Leucetta* to include "Leuconidæ with triacts or tetracts or both."

Dendy [1893 A] included Haeckel's species of *Leucetta* in the genus *Leucandra*, on the ground that the mere absence of quadri-radiate or oxeote spicules, or both, could not be regarded as of generic significance.

As a result of further study of the Calcarea, we are convinced that the genus *Leucandra*, as used hitherto by Dendy, is not a natural one, but must be subdivided, although on lines different from any that have previously been suggested. It appears to us that certain species, namely those which we now assign to *Leucetta*, have originated, quite independently of the remainder, from the homocœl sponges through a leucascid ancestry, and have consequently never passed through a *Sycon* stage in their phylogeny. The species in question are characterised by their equiangular triradiates, and by the absence of any trace of the typical *Sycon* skeleton.

As regards the canal system, it appears that the same course of evolution, from a condition with elongated and more or less radially arranged flagellate chambers, to a condition with small scattered spherical chambers, has taken place in both cases, so that there has been a very complete convergence between the genera *Leucetta* and *Leucandra* as now understood by us. The true Leucandras, however, are distinguished by more or less distinct traces of the skeletal structure exhibited by their syconoid ancestors.

This view, so far as our present information goes, is supported by histological evidence; for, as already indicated, the position of the nucleus of the collared cells in *Leucetta* is basal, while in typical Leucandras it appears to be apical.

We also include in the genus *Leucetta*, as now conceived, certain species which we have hitherto regarded as belonging to the genus *Leucilla*. These species are characterised by the development to a varying extent of an inwardly pointing apical ray on some of the triradiates of the dermal cortex. They are to be distinguished from the true Leucillas on the same grounds as those on which the other Leucettas are distinguished from the true Leucandras, and we do not consider the mere presence of such apical rays by itself as a sufficient justification for generic separation.

As we are taking Haeckel's type species of *Leucetta* as the type of the genus as understood by us, we consider that we are justified in retaining his name for the genus, although that name has been used in different senses by subsequent writers.

We allocate the following species to this genus :—

#### SECTION A. Without oxea.

##### 1. *L. CHAGOLENSIS* Dendy.

*Leucetta chagolensis* Dendy [1913].

2. *L. FLORIDANA* Haeckel.  
*Leucaltis floridana* Haeckel [1872].
3. *L. INFREQUENS* Row.  
*Leucetta infrequens* Row [1913 MS.].
4. *L. MICRORAPHIS* Haeckel.  
*Leucetta primigenia* var. *microraphis* Haeckel [1872].  
*Leuconia dura* Poléjaeff [1883], *fide* Dendy [1892 B].
5. *L. PRIMIGENIA* Haeckel. Type species of the genus.  
*Sycothamnus fruticosus* Haeckel [1870], *fide* Haeckel [1872].  
*Lipostomella clausa* Haeckel [1870], *fide* Haeckel [1872].  
*Leucetta primigenia* Haeckel [1872].  
*Leuconia fruticosa* Poléjaeff [1883].

Haeckel's two earlier names are *nomina nuda*, as they were not accompanied by diagnoses, and we have rejected them, although Poléjaeff has revived one of them.

6. *L. PYRIFORMIS* Dendy.  
*Leucetta pyriformis* Dendy [1913].
7. *L. PROLIFERA* Carter.  
*Teichonella prolifera* Carter [1878].  
*Leucilla prolifera* Dendy [1892 B].  
*Leucetta prolifera* Row [1913 MS.].
8. *L. SOLIDA* O. Schmidt.  
*Grantia solida* O. Schmidt [1862].  
*Leuconia nivea* J. E. Gray [1867], *fide* Haeckel [1872].  
*Leucaltis solida* Haeckel [1872].
9. *L. TRIGONA* Haeckel.  
*Leucetta trigona* Haeckel [1872].

SECTION B. With large, usually radially arranged oxea, but without microxea.

10. *L. CARTERI* Dendy.  
*Leucaltis floridana* var. *australiensis* Carter [1885-1886].  
*Leucandra carteri* Dendy [1892 B].

SECTION C. With both large oxea and microxea.

11. *L. EXPANSA* Row.  
*Leucetta expansa* Row [1913 MS.].

The following species is doubtfully assigned to *Leucetta* :—

12. *L. HOMORAPHIS* Poléjaeff.  
*Pericharax carteri* var. *homoraphis* Poléjaeff [1883].

The name *carteri* cannot be used for this species, as it is already employed in this genus.

## Genus 8. PERICHARAX Poléjaeff [1883].

*Diagnosis.* Sponge colony individualised, with large central cavity (probably a pseudogaster) opening by a wide vent and surrounded by a very thick wall. Canal system leucoid, with sub-spherical, scattered, flagellate chambers, and with subdermal cavities whose walls are supported by a special skeleton derived partly from the inturned rays of tangential dermal triradiates. Skeleton of the chamber layer confused, composed of equiangular triradiates of two very different sizes.

For illustrations of this genus see Poléjaeff [1883] and Dendy [1913].

This genus was proposed by Poléjaeff [1883] for a species, *Pericharax carteri*, from Tristan da Cunha, but recent authors, for the most part, have not accepted it. The discovery by the 'Sealark' Expedition of the original species, and of a new one closely allied to it, has enabled us to make a careful study of the question, and we are convinced that the genus is valid. The position which we assign to it is justified, not only by the character of the skeleton, but also, as in the case of *Leucetta*, by the basal position of the nucleus of the collared cells in both species.

The dermal triradiates in both species are very curious spicules, with a strong tendency to irregular curvature of the rays, often resulting in one or more of them dipping down deeply between the subdermal cavities.

*Pericharax heteroraphis* (Poléjaeff's *P. carteri* var. *heteroraphis*) must be taken as the type of the genus. The same author's *P. carteri* var. *homoraphis*, as we have noted above, appears to be quite distinct, and is not a *Pericharax* at all, but probably a *Leucetta*. *Pericharax poléjaevi* Breitung [1896 A], placed by its author in this genus on account of the presence of subdermal cavities, is really a typical *Leucandra*, for the presence of subdermal cavities without a special supporting skeleton cannot be regarded as of generic importance. Poléjaeff also included in the genus Haeckel's *Leucandra cucumis*, the position of which is discussed by us under the genus *Paraleucilla*.

We recognise the following as species of this genus:—

1. *P. HETERORAPHIS* Poléjaeff. Type species of the genus.  
*Pericharax carteri* var. *heteroraphis* Poléjaeff [1883].
2. *P. PEZIZA* Dendy.  
*Pericharax peziza* Dendy [1913].

## Family 3. LEUCALTIDÆ nov.

*Diagnosis.* Sponge colony tubular and ramified, or even anastomosing, with many oscula, or individualised with large central cavity and single osculum. Wall of colony composed of at least two distinct layers, namely, a dermal cortex with strongly developed skeleton of tangential radiates, and a chamber layer with a skeleton greatly reduced or even absent. A thin gastral cortex or membrane may or may not be present. Skeleton composed, mainly at any rate, of equiangular radiates. No sub-gastral sagittal radiates. Nuclei of collared cells probably always basal.

The members of this family appear to have been derived from a *Dendya*-like ancestor by the development of a thick dermal cortex with a strongly developed cortical skeleton, and the consequent more or less complete reduction of the no longer necessary skeleton of the chamber layer. As in other families of Calcarea, the flagellate chambers range from greatly elongated and even branched, and more or less radially arranged, to small, sub-spherical and scattered.

Bidder [1898] has already pointed out that the nuclei of the collared cells in *Leucaltis clathria* Haeckel (*Heteropegma nodus-gordii* Poléjaeff) are basal in position, and we are able to confirm this observation and to add that they are basal also in *Leucettusa dictyogaster* Row [1913 MS.].

The reduction of the skeleton of the chamber layer, correlated with the development of a thick dermal cortex with a special cortical skeleton, finds its parallel in the genus *Grantiopsis* amongst the Grantiidæ, but in that case the syconoid ancestry is very clearly indicated in the remains of an articulate tubar skeleton, while in *Leucaltis* the vestigial skeleton of the chamber layer shows no indications whatever of an articulate origin.

The characters above mentioned, in our opinion justify the close association of *Leucaltis* with *Leucettusa*, and the wide separation of these genera from both *Leucandra* and *Leucilla* in our scheme of classification.

We prefer to derive the Leucaltidæ directly from a *Dendya*-like ancestor, rather than indirectly through *Leucascus*, because *Leucaltis* still preserves the more primitive type of radial colony formation with what we presume to be a true central gastral cavity, while *Leucascus* has adopted a massive type of colony formation in which the exhalant canals are possibly to be regarded as pseudogastral in nature.



Genus 9. *LEUCALTIS* Haeckel [1872] (emend.).*Heteropegma* Poléjaeff [1883].

*Diagnosis.* Sponge colony tubular, ramified and anastomosing, with many oscula. Flagellate chambers elongated and branched, more or less radially arranged round the central gastral cavities of the tubes.

For illustrations of this genus see Poléjaeff [1883] and Dendy [1893 A].

Dendy [1892 B, 1893 A] placed this genus in the family Amphoriscidae, on account of the large subdermal quadriradiates possessed by the only known species. He also regarded the vestigial triradiates of the skeleton of the chamber layer as the remnants of an articulate tubar skeleton, being misled by the radial arrangement of the flagellate chambers. We are now convinced that in both these respects he was wrong, and that the genus is probably, as Bidder [1898] maintained, related to *Dendya*, from which it has been directly derived without passing through an intermediate syconoid stage.

In arriving at this conclusion we lay great stress upon the regular and equiangular form of the triradiates of both the chamber layer and the dermal cortex, and also upon the basal position of the nuclei of the collared cells. The genus may, in fact, almost be regarded as a *Dendya* with a thick dermal cortex.

Dendy [1913] has shown that only one species can be recognised in the genus. A re-investigation of the type specimen of Haeckel's *Leucaltis clathria* has convinced us that it is not only generically, but also specifically identical with Poléjaeff's *Heteropegma nodus-gordii*, and the latter name thus becomes a synonym of *Leucaltis clathria* Haeckel. As the other species of Haeckel's genus *Leucaltis* must be removed to older genera, *L. clathria* must be taken as the typical species, and we are therefore unable to retain Poléjaeff's name *Heteropegma*. Again, Carter's *Clathrina latitubulata* is only a variety of *Leucaltis clathria*, differing in some slight details of spiculation. Mr. Carter seems to have been led into provisionally placing his species in the genus *Clathrina* by the external form of the whole colony, which resembles a reticulate *Clathrina* on a gigantic scale. The reticulation, however, is not composed of simple ascon tubes as in *Clathrina*, but of a colony of a higher order, with numerous true ascon tubes lying in the thickness of the wall. Finally, Ridley's *Leucaltis bathybia* var. *mascarenica* is evidently, from his description, and from the slides which we have been able to examine, nothing but the same species.

The extent to which apical rays are developed on the tangential radiates of the dermal cortex varies greatly in different individuals.

We recognise only the following species in the genus:—

1. *L. CLATHRIA* Haeckel.

*Leucaltis clathria* Haeckel [1872].

*Heteropegma nodus-gordii* Poléjaeff [1883], *vide* Dendy [1913].

*Clathrina latitubulata* Carter [1885-1886], *vide* Dendy [1913].

*Leucaltis bathybia* var. *mascarenica* Ridley [1884], *vide* Dendy [1913].

*Leucaltis clathria* Dendy [1913].

Genus 10. *LEUCETTUSA* Haeckel [1872] (emend.).

*Leucetta* Poléjaeff [1883].

*Diagnosis.* Sponge colony individualised, with definite external form and large central cavity opening by a large single osculum. Canal system leuconoid.

For illustrations of this genus see Poléjaeff [1883] under the name *Leucetta*, and Row [1913 MS.].

The remarkable reticulate type of colony formation found in *Leucaltis* prevents us from regarding that genus as directly ancestral to *Leucettusa*, but as regards canal system the two are related in the same way as *Grantia* and *Leucandra*.

Within the limits of the genus *Leucettusa*, however, we find considerable variation with regard to the form of the flagellate chambers. Poléjaeff's figure of the canal system of *Leucettusa* (*Leucetta*) *vera* shows the flagellate chambers in the outer part of the chamber layer elongated and radially arranged, while those in the inner part are subspherical and scattered, so that this species appears to be intermediate between *Leucaltis* and the more typical *Leucettusas* in this respect.

*Leucettusa* (*Leucetta*) *haeckeliana*, on the other hand, has the flagellate chambers all small and subspherical, and lying in the irregular trabeculae of the chamber layer, which are separated by very wide, irregular exhalant lacunae. In *Leucettusa dictyogaster* Row [1913 MS.] the trabeculae bearing the flagellate chambers form a network which almost completely blocks up the central gastral cavity as an altogether askeletal layer. A section of this askeletal chamber layer, isolated from the cortex, would be almost indistinguishable from a similar section of *Oscarella*, which also has large collared cells with basally placed nuclei, so that the possibility presents itself that *Oscarella* may be nothing but a calcareous sponge which has lost the whole of its skeleton.

We also find in the genus *Leucettusa* various stages in the development of the subdermal quadriradiate spicules, which are entirely absent in *L. corticata* and *L. dictyogaster*, very sparse in *L. haeckeliana* and large and very numerous in *L. vera*. As

already indicated, we no longer consider the presence of subdermal quadriradiates, taken by itself, to be a character of generic importance, being convinced that the addition of an apical ray to a triradiate spicule may take place whenever and wherever it may be required.

It will have been noticed that our genus *Leucettusa* is identical in scope with Poléjaeff's *Leucetta* [1883], but as we have found it necessary to retain Haeckel's name *Leucetta* for another genus, as previously explained, we have been obliged to adopt his subgeneric name for the group of species which Poléjaeff quite rightly separated out.

We recognise the following species as belonging to this genus:—

SECTION A. Without oxea.

1. *L. CORTICATA* Haeckel. Type species of the genus.  
*Leucetta corticata* Haeckel [1872].
2. *L. HAECKELIANA* Poléjaeff.  
*Leucetta haeckeliana* Poléjaeff [1883].
3. *L. IMPERFECTA* Poléjaeff.  
*Leucetta imperfecta* Poléjaeff [1883].
4. *L. SAMBUCUS* Preiwisch.  
*Leucetta sambucus* Preiwisch [1904].
5. *L. VERA* Poléjaeff.  
*Leucetta vera* Poléjaeff [1883].

SECTION B. With microxea but without large oxea.

6. *L. DICTYOGASTER* Row.  
*Leucettusa dictyogaster* Row [1913 MS.].

Family 4. MINCHINELLIDÆ nov.

*Lithonina* Döderlein [1892].

*Lithoninae* Kirkpatrick [1911 A].

*Diagnosis.* Canal system leuconoid (in all known forms and presumably always so). Main skeleton composed of quadriradiates cemented together in various ways by calcareous cement. Apparently without subgastral sagittal radiates. Nuclei of collared cells (probably always) basal.

We have been able, owing to the kindness of Mr. Kirkpatrick, to examine preparations of *Minchinella* and *Murrayona*, in which the collared cells are sufficiently well preserved to enable us to determine the position of the nucleus. We find that this is basal in both cases, whereas in *Lelapia* we find it to be apical. As

*Lelapia* differs widely in other characters also from both *Minchinella* and *Murrayona*, we are forced to the conclusion that the so-called Pharetronid sponges are at least diphyletic in origin, and we have removed the *Lelapiidae* to a position in the Sycettid line of descent. We shall, however, discuss the question further under the head of phylogeny.

The genera *Minchinella*, *Petrostroma* and *Plectroninia* all agree in the possession of a stony skeleton composed of fused quadriradiates, and thus differ widely from *Murrayona*. We therefore unite them in one family under the name Minchinellidæ, while relegating *Murrayona* to a special family of its own.

#### Genus 11. MINCHINELLA Kirkpatrick [1908].

*Diagnosis.* Sponge lamellar, with pore-bearing chimneys on one side and oscular chimneys on the other. The quadriradiates of the main skeleton cemented together into a compact network and completely embedded in the enveloping cement. Dermal skeleton of radiates, including tuning-fork spicules, and oxea.

For illustrations of this genus see Kirkpatrick [1908].

The only known species of the genus is:—

1. *M. LAMELLOSA* Kirkpatrick.

*Minchinella lamellosa* Kirkpatrick [1908].

#### Genus 12. PETROSTROMA Döderlein [1892].

*Diagnosis.* The quadriradiates of the skeleton of the chamber-layer fused together laterally by calcareous cement into a network. Dermal skeleton of separate quadriradiates and triradiates and bunches of tuning-fork spicules.

For illustrations of this genus see Döderlein [1897].

The only known recent species of this genus is:—

1. *P. SCHULZEI* Döderlein.

*Petrostroma schulzei* Döderlein [1892].

#### Genus 13. PLECTRONINIA Hinde [1900].

*Diagnosis.* Quadriradiates of the main skeleton with their facial rays truncated or expanded terminally and fused end to end with the facial rays of adjacent spicules, while the apical rays remain free and pointed. Dermal skeleton of separate radiates, including tuning-fork spicules, and oxea.

For illustrations of this genus see Kirkpatrick [1900 B].

The only known recent species of this genus are:—

1. *P. DEANSII* Kirkpatrick.  
*Plectroninia deansii* Kirkpatrick [1911 A].
2. *P. HINDEI* Kirkpatrick.  
*Plectroninia hindei* Kirkpatrick [1900 B].

The type of the genus is *P. halli* Hinde [1900], a fossil species from the Eocene of Victoria.

#### Family 5. MURRAYONIDÆ nov.

*Murrayonina* Kirkpatrick [1911 A].

*Diagnosis.* Canal system presumably always leuconid. Skeleton of the chamber layer a rigid calcareous network, not composed of spicules. No subgastral sagittal radiates. Dermal skeleton composed chiefly of overlapping calcareous scales. Nuclei of collared cells basal.

This family seems to mark the culminating point of the Leucascid-Leucettid line of evolution, and there is no other known calcareous sponge with a skeleton so highly specialised as *Murrayona*.

It is at any rate possible that the aspicular main skeleton of *Murrayona* is derived from the cement-covered fibres of spicules which are known to occur in many of the fossil forms, by a gradual disappearance of the spicular core, analogous to what we find among the Chalininae, during the evolution of the group. It is, however, a far cry from the one to the other, and we do not doubt that there are many other ways in which the Murrayonid skeleton may have arisen.

#### Genus 14. MURRAYONA Kirkpatrick [1910]

*Diagnosis.* With a definite pore-zone in which the dermal skeleton consists of small triradiates. Tuning-fork spicules present beneath the dermal scales.

For illustrations of this genus see Kirkpatrick [1910]

The only known species of this genus is:—

1. *M. PHANOLEPIS* Kirkpatrick.  
*Murrayona phanolepis* Kirkpatrick [1910]

## Family 6. SYCETTIDÆ Dendy [1892 B].

*Diagnosis.* Flagellate chambers elongated, arranged radially around a central gastral cavity, their ends projecting more or less on the dermal surface and not covered over by a continuous dermal cortex strengthened by tangential dermal spicules. Tubar skeleton articulate, with subgastral sagittal radiates. Collared cells usually confined to the radial chambers in the adult, and probably always with apical nuclei.

The Sycettidæ, in our opinion, form the starting point of a distinct line of evolution, embracing the great majority of the recent heterocœl Calcareæ. This view is supported by the fact that in all the 44 species of Sycettidæ, Heteropiidæ, Grantiidæ, Amphoriscidæ and Lelapiidæ in which it has been determined, the position of the nuclei of the collared cells is apical.

It would appear therefore that this line of evolution must have originated from homocœl ancestors with apical nuclei. Such forms are known to occur amongst the simple (*i. e.* non-reticulate) species of *Leucosolenia*, as for example *L. lucasi* and *L. bella*.

Why the transition from the simple homocœl to the radial heterocœl condition originally took place we can only guess. That it was by the outgrowth of radial buds is clearly indicated, however, by the ontogeny of the genus *Sycon* (compare Schulze [1875]). No real intermediate forms are known, however, for we can no longer consider that *Dendya* is on the same line of ancestry, while von Lendenfeld's *Homoderma sycandra* is already a highly specialised *Sycon* with the typical *Sycon* skeleton, and differing from other *Sycons* only in the persistence of the collared cells in the central gastral cavity. According to Minchin the Sycettidæ have arisen from his homocœl family Leucosoleniidæ, but we have already endeavoured to shew that in the present state of our knowledge it is impracticable to distinguish this family from his Clathrinidæ.

The presence of sagittal radiates in which the oral angle is wider than the lateral angles appears to be a very constant character of the Sycettidæ and their derivatives. It would seem, further, that the occurrence of such spicules in the articulate tubar skeleton is correlated with the development of very definite radial tubes, but it is extremely difficult, at any rate in practice, to distinguish such spicules individually from equiangular radiates which have become sagittal by bending of the oral rays. The presence of subgastral sagittal radiates is, however, especially characteristic of this line of evolution. The oxeote type of spicule also tends to assume more importance in the skeleton of this family than in the Leucascidæ and Leucaltidæ, in which families it but rarely occurs.

## Genus 15. SYCETTA Haeckel [1872] (emend.).

*Diagnosis.* The radially arranged flagellate chambers always completely separate from one another, and never possessing tufts of oxea at their distal ends. With no properly defined inhalant canals leading to the prosopyles:

For illustrations of this genus see Haeckel [1872] under *Sycaltis conifera* and *Sycetta primitiva*.

This is the simplest of all the genera with syconoid canal system, its primitive nature being shown by the absence of fusion between the flagellate chambers and by the absence of tufts of oxea at their distal ends, unless, indeed, this absence is due to the disappearance of ancestral oxea.

*Sycetta asconoides* Breiufuss [1896 B], to judge by the published description, apparently occupies an intermediate position between *Sycetta* and *Sycon*, as these genera are understood by us. The description states that the flagellate chambers are fused together laterally, but that they have no tufts of oxea at their distal ends. During a recent visit to Berlin, however, one of us (Row) had the opportunity of examining one of the type slides of this species, and found that Breiufuss had overlooked the presence of a few tangentially placed dermal tirradiates. The occurrence of these spicules, of course, places the species in the genus *Grantia* in the family Grantiidae, of which it is one of the simplest forms.

We include the following species in this genus:—

## 1. S. CONIFERA Haeckel.

*Sycaltis conifera* Haeckel [1872].

## 2. S. PRIMITIVA Haeckel. Type species of the genus

*Sycetta primitiva* Haeckel [1872].

## 3. S. SAGITTIFERA Haeckel.

*Sycetta sagittifera* Haeckel [1872].

## Genus 16. SYCON Risso [1826] (emend.).

*Diagnosis.* Radial chambers usually more or less united at places where they come into contact with one another, and always crowned distally with tufts of oxeote spicules. Properly defined inhalant canals usually present, the outer ends of which may be covered by a thin pore-bearing dermal membrane without special skeleton.

For illustrations of the structure of this genus see Schulze [1875] and Dendy [1893 A].

As pointed out by Dendy [1893 A] the most characteristic feature of this genus is afforded by the tufts of oxeote spicules which crown the distal ends of the radial chambers, taken in

conjunction with the absence of a dermal cortical, as distinct from a tubar, skeleton. In the more specialised species a pore-bearing dermal membrane stretches between the distal ends of the radial chambers, covering over the ends of the inhalant canals, but this contains no special skeleton of its own. The flagellate chambers may also exhibit a considerable amount of branching towards their distal extremities, but they never lose their elongated character and radial arrangement.

The genus is sharply distinguished from *Sycetta* by the presence of the tufts of oxea at the distal ends of the chambers, less sharply from *Grantia* by the absence of a special dermal cortical skeleton.

We include in our conception of the genus *Sycon* von Lendenfeld's genera *Homoderma* and *Sycantha*, and Jenkin's *Tenthrenodes antarcticus*, *Streptoconus australis* and *Hypodictyon longstaffi*. We have already mentioned that *Homoderma* is merely a *Sycon* with persistent collared cells in the central gastral cavity. Jenkin [1908 B] has shown conclusively that *Sycantha tenella* is a typical *Sycon*, but has erected a new genus *Tenthrenodes* for "Sycettidae with linked chambers," an almost identical character with that on which the genus *Sycantha* was founded; and although Dendy [1893 A] retained *Sycantha* on these grounds, we no longer consider that such "linking" can be regarded as of generic importance. We may point out here that *Tenthrenodes scotti*, the other species included by Jenkin in his genus, is placed by us in the genus *Grantia*, on account of the presence of tangential triradiates in the dermal cortex. *Streptoconus australis* and *Hypodictyon longstaffi* are "chiact"-bearing forms which were placed by Jenkin in his family Chiphoridae.

We assign the following species to the genus:—

1. *S. ALOPECURUS* Haeckel.  
*Sycon alopecurus* Haeckel [1870].  
*Sycandra ampulla* var. *alopecurus* Haeckel [1872].
2. *S. AMPULLA* Haeckel.  
*Sycarium ampulla* Haeckel [1870].  
*Sycon petiolatus* O. Schmidt MS., *fide* Haeckel [1872].  
*Sycon petiolatum* Haeckel [1870], *fide* Haeckel [1872].  
*Sycandra ampulla* Haeckel [1872].
3. *S. ANTARCTICUM* Jenkin.  
*Tenthrenodes antarcticus* Jenkin [1908 B].
4. *S. ARCTICUM* Haeckel.  
*Sycon arcticum* Haeckel [1870].  
*Sycon raphanus* O. Schmidt [1870], *fide* Haeckel [1872].  
*Sycandra arctica* Haeckel [1872].
5. *S. ASPERUM* Gibson.  
*Sycandra aspera* Gibson [1886].



6. S. AUSTRALE *Jenkin*.  
*Streptoconus australis* Jenkin [1908 B].
7. S. BARBADENSE *Schuffner*.  
*Sycandra barbadensis* Schuffner [1877].
8. S. BOOMERANG *Dendy*.  
*Sycon boomerang* Dendy [1892 B].
9. S. BOREALE *Schuffner*.  
*Sycandra borealis* Schuffner [1877].
10. S. CAMINATUM *Thacker*.  
*Sycon caminatum* Thacker [1908].
11. S. CARTERI *Dendy*.  
*Sycon carteri* Dendy [1892].  
*Sycantha tenella* von Lendenfeld MS., *fide* Breitfuss [1897].  
*Sycon carteri* Row [1913 MS.].
12. S. CILIATUM *Fabricius*.  
*Spongia ciliata* Fabricius [1780].  
*Sycum giganteum* Haeckel [1870], *fide* Haeckel [1872].  
*Sycocystis oviformis* Haeckel [1870], *fide* Haeckel [1872].  
*Sycodendrum ramosum* Haeckel [1870], *fide* Haeckel [1872].  
*Sycandra ciliata* Haeckel [1872].
13. S. COACTUM *Urban*.  
*Sycandra coacta* Urban [1905].
14. S. COMMUTATUM *Haeckel*.  
*Sycandra coronata* var. *commutata* Haeckel [1872].
15. S. COMPACTUM *Lambe*.  
*Sycon compactum* Lambe [1893].
16. S. CORONATUM *Ellis and Solander*.  
*Spongia coronata* Ellis and Solander [1786].  
*Grantia ciliata* Bowerbank [1864-1882], *fide* Haeckel [1872].  
*Sycandra coronata* Haeckel [1872].  
*Sycon coronatum* Dendy [1892 B].
17. S. EGLINTONENSIS *Lambe*.  
*Sycon eglintonensis* Lambe [1900 B].
18. S. ELEGANS *Bowerbank*.  
*Dunstervillia elegans* Bowerbank [1845].  
*Dunstervillia lanzerotæ* Haeckel [1870], *fide* Haeckel [1872].  
*Sycandra elegans* Haeckel [1872].

19. *S. ENSIFERUM* Dendy.*Sycon ensiferum* Dendy [1892 B].*Sycon ensiferum* Row [1913 MS.].20. *S. FORMOSUM* Haeckel.*Dunstervillia formosa* Haeckel [1870].*Sycandra elegans* var. *formosa* Haeckel [1872].21. *S. GELATINOSUM* de Blainville.*Alcyoncellum gelatinosum* de Blainville [1834-1847].*Grantia virgultosa* Bowerbank MS., *fide* Haeckel [1872].*Sycandra alcyoncellum* Haeckel [1872], *fide* Dendy [1892 B].*Sycandra arborea* Haeckel [1872], *fide* Dendy [1892 B].*Sycon gelatinosum* Dendy [1892 B].22. *S. GIGANTEUM* Dendy.*Sycon giganteum* Dendy [1892 B].23. *S. HELLERI* von Lendenfeld.*Sycandra helleri* von Lendenfeld [1891].24. *S. HUMBOLDTII* Risso. Type species of the genus.*Sycon humboldtii* Risso [1826].*Dunstervillia coreyrensis* O. Schmidt [1862], *fide* Haeckel [1872].*Dunstervillia schmidtii* Haeckel [1870], *fide* Haeckel [1872].*Sycandra humboldtii* Haeckel [1872].25. *S. IMPLETUM* Haeckel.*Artynas villosus* Haeckel [1870], *fide* Haeckel [1872].*Sycandra villosa* var. *impletum* Haeckel [1872].26. *S. INCONSPICUUM* von Lendenfeld.*Sycandra inconspicua* von Lendenfeld [1885 B].27. *S. INCRUSTANS* Breitfuss.*Sycon incrustans* Breitfuss [1898 E].28. *S. KARAJAKENSE* Breitfuss.*Sycon karajakense* Breitfuss [1897].29. *S. KERGUELENSIS* Urban.*Sycon kerguelensis* Urban [1908].30. *S. LAMBEI*, *sp. n.**Sycon asperum* Lambe [1896].

The new specific name has been given to the above species on account of the fact that the name *asperum* is already occupied in this genus. (See above.)

31. *S. LANCEOLATUM* Haeckel.*Sycon lanceolatum* Haeckel [1870].*Sycandra ciliata* var. *lanceolata* Haeckel [1872].

32. S. LENDENFELDI *Row*.  
*Sycon lendenfeldi* Row [1913 MS.].
33. S. LINGUA *Haeckel*.  
*Sycortis lingua* Haeckel [1872].
34. S. LONGSTAFFI *Jenkin*.  
*Hypodictyon longstaffi* Jenkin [1908 B].
35. S. MAXIMUM *Haeckel*.  
*Sycandra arctica* var. *maxima* Haeckel [1872].
36. S. MINUTUM *Dendy*.  
*Sycon minutum* Dendy [1892 B].
37. S. MUNDULUM *Lambe*.  
*Sycon mundulum* Lambe [1900 B].
38. S. MUNITUM *Jenkin*.  
*Sycon munitum* Jenkin [1908 A].
39. S. ORNATUM *Kirk*.  
*Sycon ornatum* Kirk [1897].
40. S. OVATUM *Haeckel*.  
*Sycum ovatum* Haeckel [1870].  
*Sycandra ciliata* var. *orata* Haeckel [1872].
41. S. PARVULUM *Preiwisch*.  
*Sycandra parvula* Preiwisch [1904].
42. S. PEDICELLATUM *Kirk*.  
*Sycon pedicellatum* Kirk [1897].
43. S. PETIOLATUM *Haeckel* [1870].  
*Sycum petiolatum* Haeckel [1870].  
*Sycandra ampulla* var. *petiolata* Haeckel [1872].
44. S. POLARE *Haeckel*.  
*Sycandra arctica* var. *polaris* Haeckel [1872].
45. S. PROBOSCIDEUM *Haeckel*.  
*Syconella proboscidea* Haeckel [1870].  
*Sycandra raphanus* var. *proboscidea* Haeckel [1872].
46. S. PROCUMBENS *Haeckel*.  
*Sycum procumbens* Haeckel [1870].  
*Sycandra raphanus* var. *procumbens* Haeckel [1872].
47. S. PROTECTUM *Lambe*.  
*Sycon protectum* Lambe [1896].
48. S. QUADRANGULATUM *O. Schmidt*.  
*Syconella quadrangulata* O. Schmidt [1868].  
*Sycandra quadrangulata* Haeckel [1872].

49. S. RAMOSUM *Haeckel*.  
*Sycandra ramosa* Haeckel [1872].  
*Leuckartea natalensis* Michluch-Maclay MS., *fide* Haeckel [1872].
50. S. RAMSAYI *von Lendenfeld*.  
*Sycandra ramsayi* von Lendenfeld [1885 A].
51. S. RAPHANUS *O. Schmidt*.  
*Sycon raphanus* O. Schmidt [1862].  
*Spongia inflata* Delle Chiaje [1828], *fide* Haeckel [1872].  
*Sycarium vesica* Haeckel [1870], *fide* Haeckel [1872].  
*Sycandra raphanus* Haeckel [1872].
52. S. SCHMIDTII *Haeckel*.  
*Sycandra schmidtii* Haeckel [1872].  
This species must be distinguished from *Dunsterrillia schmidtii* Haeckel, a synonym of *Sycon humboldtii* Risso.
53. S. SCHUFFNERI, *sp. n.*  
*Sycandra quadrata* Schuffner [1877].  
We propose this new name in order to avoid confusion with Haeckel's variety *quadrata* of *Sycon quadrangulatum* (O. Schmidt).
54. S. SETOSUM *O. Schmidt*.  
*Sycon setosum* O. Schmidt [1862].  
*Sycandra setosa* Haeckel [1872].
55. S. STAURIFERUM *Preiwisch*.  
*Sycandra staurifera* Preiwisch [1904].
56. S. SUBHISPIDUM *Carter*.  
*Grantia subhispida* Carter [1885-1886].
57. S. SYCANDRA *von Lendenfeld*.  
*Homoderma sycandra* von Lendenfeld [1885 A].  
*Leucosolenia* (?) *sycandra* Dendy [1891 A].  
See also Row [1913 MS.], under *Sycon lendenfeldi*.
58. S. TABULATUM *Schuffner*.  
*Sycandra tabulata* Schuffner [1877].  
Very probably identical with Haeckel's variety *tabulata* of *Sycon elegans* Bowerbank.
59. S. TENELLUM *von Lendenfeld*.  
*Sycantha tenella* von Lendenfeld [1891].  
*Sycon tenellum* Jenkin [1908 B].
60. S. TERGESTINUM *Haeckel*.  
*Sycon tergestinum* Haeckel [1870].  
*Sycandra raphanus* var. *tergestina* Haeckel [1872].

61. S. TESSELLATUM *Bowerbank*.  
*Grantia tessellata* Bowerbank [1864-1882].  
*Sycandra elegans* var. *tessellata* Haeckel [1872].
62. S. TESSERARIUM *Haeckel*.  
*Sycandra quadrangulata* var. *tesseraria* Haeckel [1872].
63. S. TUBA von *Lendenfeld*.  
*Sycandra tuba* von Lendenfeld [1891].
64. S. TUBULOSUM *Haeckel*.  
*Sycandra coronata* var. *tubulosa* Haeckel [1872].
65. S. VERUM *Row*.  
*Sycon verum* Row [1913 MS.].
66. S. VILLOSUM *Haeckel*.  
*Sycarium villosum* Haeckel [1870].  
*Sycum clavatum* Haeckel [1870], *fide* Haeckel [1872].  
*Sycandra villosa* Haeckel [1872].
67. S. VIRGULTOSUM *Haeckel*.  
*Sycandra alcyoncellum* var. *virgultosa* Haeckel [1872].

Genus 17. SYCANDRA Haeckel [1872] (emend.).

*Diagnosis.* The radially arranged flagellate chambers more or less united where they come into contact with one another. Gastral cavity traversed by strands of tissue containing bundles of parallel oxea and forming a more or less strongly developed endogastric network. Radially arranged dermal oxea present.

For illustrations of this genus see Haeckel [1872].

We propose to use this generic name for O. Schmidt's *Ute utriculus* (= *Sycandra utriculus* Haeckel), which is sufficiently sharply distinguished by its skeletogenous endogastric network. There is only one other species in which this character is known to occur, namely *Leucettaga loculosa*, a member of the family Grantiidae.

The species of *Sycandra* which precede *S. utriculus* in Haeckel's monograph having been relegated to earlier genera such as *Sycon*, *Ute* and *Grantia*, this species becomes the type of the genus.

The only known species is :—

1. S. UTRICULUS *O. Schmidt*.  
*Ute utriculus* O. Schmidt [1870].  
*Sycandra utriculus* Haeckel [1872].

## Family 7. HETEROPIIDÆ Dendy [1892 B].

*Diagnosis.* With a distinct and continuous dermal cortex covering over the chamber-layer and pierced by inhalant pores. Subgastral sagittal and subdermal pseudosagittal radiates are present. Flagellate chambers varying from elongated and radially arranged to spherical and irregularly scattered. With or without an articulate tubar skeleton. Nuclei of collared cells probably always apical.

This family is identical in scope with the family as originally proposed by Dendy [1892 B], and the difference now made in the diagnosis is due to the fact that our conception of the subdermal triradiates has changed. Up to the present we have considered the characteristic subdermal spicules in this family as being truly sagittal, with the basal ray centripetally directed. We have now convinced ourselves, however, by a careful examination of a number of species, that this is not the case, but that the inwardly pointing ray is really one of the oral rays, and that the original basal ray has taken on the appearance and position of an oral ray. In other words, we find the clearest evidence that these spicules are derived from ordinary distally situated triradiates of the articulate tubar skeleton, which have undergone rotation followed by the acquisition of a secondary pseudo-symmetry. We therefore propose for them the name of *pseudosagittal*. It will be remembered that Poléjaeff [1883] recognised, in the case of *Grantessa* (*Amphoriscus*) *poculum* and *G. flamma*, that the subdermal triradiates are not ordinary sagittal spicules and that the centripetal ray is really one of the lateral (=oral) rays and not the basal ray. He, however, considered that they are triradiates of the dermal cortex which have undergone re-orientation, and not, as we maintain, tubar triradiates.

Various species of the genus *Grantessa* show quite clearly how the change has taken place. In *Grantessa hirsuta* we have a primitive type with long chambers and an articulate skeleton of many joints. At the distal ends of the chambers are tufts of oxea, towards which the basal rays of the triradiates of the distal joint of the tubar skeleton are inclined, as indeed occurs also in the genera *Sycon* and *Grantia*. Moreover, the whole spicule has become tilted until in some cases one of the original oral rays has assumed a position at right angles to the surface, while the other has come to lie nearly parallel to the surface, where it probably serves to guard the entrance to the inhalant canal. In more advanced cases, such as *Grantessa sacca* and *G. hispida*, the great elongation of the now inwardly directed oral ray increases the resemblance to an ordinary sagittal spicule, but a characteristic asymmetry of the outwardly directed (apparent oral) rays, accompanied by a definite kink or angulation in one of them,

(which appears to be due to change of position during individual growth), affords a clear indication of what has really taken place. Finally, in the most advanced types, such as *Grantessa intusarticulata*, we find the pseudosagittal subdermal spicules assuming great dominance, almost to the exclusion of the typical articulate tubar skeleton, so that we arrive at the so-called inarticulate type.

The development of these characteristic spicules appears to antedate the appearance of a definite dermal cortex, for we find in *Sycon ensiferum* Dendy a similar canting of certain of the distal tubar triradiates, which renders this species almost indistinguishable from *Grantessa*. Indeed, it is this out-turning of one of the rays of the distal tubar triradiates that has, in our opinion, led to the formation of a dermal cortex, probably by the drawing out of the soft tissues of the sponge with the rays in question. Thus the origin of the dermal cortex in this family would be intimately connected with the development of these subdermal pseudosagittal triradiates. In the Grantiidae, on the other hand, the dermal cortex appears to have originated in the development of tangentially placed triradiates in a previously aspicular pore-bearing dermal membrane.

These views undoubtedly tend to bridge over the gap between the Sycettidae and the Heteropiidae, and indeed the more primitive species of *Grantessa* are differentiated from *Sycon* and *Grantia* by very slight characters, and difficult to separate from them, but the rotation of the triradiates in question appears to have formed the starting point of a new line of skeletal evolution which seems to us to deserve recognition as marking a distinct family.

We consider the views here put forward as to the origin of the subdermal pseudosagittal spicules of the Heteropiidae to be more in accordance with observed facts than those previously suggested by one of us (Row 1909) in regard to the "subdermal secondary sagittal triradiates" of *Grantilla*, which seem to be pseudosagittal spicules really similar to those of *Grantessa*.

We have changed the spelling of the name of the family from Heteropidae to Heteropiidae, the latter being more in accordance with the usual practice.

#### Genus 18. GRANTESSA von Lendenfeld [1885 B] (emend.).

*Diagnosis.* Canal system syconoid. No colossal longitudinally placed oxea.

For illustrations of this genus see von Lendenfeld [1885 B] and Dendy [1893 A].

The tubar skeleton in this genus ranges from articulate, with very numerous joints, as in *Grantessa sacca*, *G. erinaceus*, *G. hirsuta* and *G. hispida*, to inarticulate or nearly so, as in *G. glabra* and

*G. polyperistomia*. This character might indeed be used as a basis for the subdivision of the genus, were it not for the impossibility of drawing a satisfactory line between the two types of tubar skeleton.

We recognise the following species as belonging to this genus:—

SECTION A. With large, usually radially arranged oxea  
but without microxea.

1. *G. COMPRESSA* Carter.  
*Heteropia compressa* Carter [1885–1886].
2. *G. ERECTA* Carter.  
*Heteropia erecta* Carter [1885–1886].
3. *G. ERINACEUS* Carter.  
*Leuconia erinaceus* Carter [1885–1886].
4. *G. FLAMMA* Poléjaeff.  
*Amphoriscus flamma* Poléjaeff [1883].
5. *G. GLABRA* Row.  
*Grantessa glabra* Row [1909].
6. *G. HASTIFERA* Row.  
*Grantilla hastifera* Row [1909].  
*Grantessa hastifera* Dendy [1913].
7. *G. HIRSUTA* Carter.  
*Hypograntia hirsuta* Carter [1885–1886].  
*Grantessa hirsuta* Row [1913 MS.].
8. *G. HISPIDA* Dendy.  
*Grantessa hispida* Dendy [1892 B].
9. *G. LANCEOLATA* Breitfuss.  
*Ebnerella lanceolata* Breitfuss [1898 B].
10. *G. NITIDA* Arnesen.  
*Ebnerella nitida* Arnesen [1901].
11. *G. PELAGICA* Ridley.  
*Nardoa pelagica* Ridley [1881].
12. *G. PLURIOSCULIFERA* Carter.  
*Heteropia pluriosculifera* Carter [1885–1886].
13. *G. POCULUM* Poléjaeff.  
*Amphoriscus poculum* Poléjaeff [1883].  
*Heteropia patulosculifera* Carter [1885–1886], *vide* Dendy [1892 B].  
*Grantessa poculum* Dendy [1892 B].



14. G. POLYPERISTOMIA *Carter*.  
*Heteropia polyperistomia* Carter [1885-1886].  
*Grantessa polyperistomia* Row [1913 MS.].
15. G. SACCA *von Lendenfeld*. Type species of the genus.  
*Grantessa sacca* von Lendenfeld [1885 B].
16. G. SYCILLOIDES *Schuffner*.  
*Sycortis sycilloides* Schuffner [1877].

SECTION B. Without large oxea, but with microxea.

17. G. INTUSARTICULATA *Carter*.  
*Hypograntia intusarticulata* Carter [1885-1886].  
*Hypograntia medioarticulata* Carter [1885-1886], *fide*  
Dendy [1892 B].  
*Grantessa intusarticulata* Dendy [1892 B].

SECTION C. With large, usually radially arranged oxea  
and with microxea.

18. G. KÜKENTHALI *Breitfuss*.  
*Ebnerella kükenthali* Breitfuss [1896 A].
19. G. PREIWISCHI, *sp. n.*  
*Ebnerella compressa* Preiwisch [1904].  
This new specific name has been given to the species, as  
*compressa* is already occupied. (See above.)
20. G. SPISSA *Carter*.  
*Heteropia spissa* Carter [1885-1886].
21. G. THOMPSONI *Lambe*.  
*Amphoriscus thompsoni* Lambe [1900 B].

SECTION D. Without any oxea.

22. G. GLACIALIS *Haeckel*.  
*Sycaltis glacialis* Haeckel [1872].
23. G. MURMANENSIS *Breitfuss*.  
*Amphoriscus murmanensis* Breitfuss [1898 B].
24. G. SIMPLEX *Jenkin*.  
*Grantessa simplex* Jenkin [1908 A].
25. G. STAURIDEA *Haeckel*.  
*Sycetta stauridea* Haeckel [1872].  
*Djeddea violacea* Michlucho-Maclay MS., *fide* Haeckel  
[1872].
26. G. ZANZIBARENSIS *Jenkin*.  
*Grantessa zanzibarensis* Jenkin [1908 A].

Genus 19. *HETEROPIA* Carter [1885-1886] (emend.).

*Diagnosis.* Canal system syconoid. Dermal cortex with colossal longitudinal oxea.

For illustrations of this genus see Row [1913 MS.].

This genus stands in precisely the same relation to *Grantessa* that *Ute* does to *Grantia*. It is noteworthy that, in all known species of this genus, as in the more highly developed species of *Grantessa*, the tubar skeleton has been reduced to the subgastral sagittal triradiates, supplemented by the subdermal pseudosagittal triradiates, and has thus become "inarticulate."

The genus *Heteropia* was diagnosed by Carter in July 1886 as follows:—"Calcareous sponges in which the wall is simply composed of sarcode supported on large sagittiform triradiates, whose heads are fixed in opposite sides of it respectively, and whose long shafts, extending perpendicularly across it, more or less overlap each other."

Most of the species placed by Carter in this genus belong to the earlier genus *Grantessa* of von Lendenfeld. There is, however, one of his species, *Heteropia ramosa*, which is distinguished by the presence of colossal longitudinal dermal oxea, and which may be regarded as the type of Carter's genus. It is curious that Mr. Carter himself [1886] described it under the name of *Aphroceras ramosa*, whilst saying at the same time that it belonged to his genus *Heteropia*.

We recognise the following species as belonging to this genus:—

## SECTION A. Without microxea.

1. *H. GLOMEROSA* Bowerbank.  
*Leuconia glomerosa* Bowerbank [1872-1876].
2. *H. RAMOSA* Carter. Type species of the genus.  
*Aphroceras ramosa* Carter [1886].
3. *H. SIMPLEX* Row.  
*Heteropia simplex* Row [1913 MS.].

## SECTION B. With microxea.

4. *H. RODGERI* Lambe.  
*Heteropia rodgeri* Lambe [1900].

Genus 20. *AMPHIUTE* Hanitsch [1894].

*Diagnosis.* Canal system syconoid. Both gastral and dermal cortices with colossal longitudinal oxea.

For illustrations of this genus see Hanitsch [1895].

This genus may be regarded as derived from some more primitive type of *Grantessa* by the addition of colossal longitudinal oxea to both dermal and gastral cortices. Those in the gastral cortex are probably to be regarded as having been derived from the oxea of the oscular fringe, by downward extension. In the only known species microxea are present, and the articulate tubar skeleton still persists.

The only known species is:—

1. A. PAULINI *Hanitsch*.  
*Amphiute paulini* Hanitsch [1894].

#### Genus 21. VOSMAEROPSIS Dendy [1892 B].

*Diagnosis.* Canal system sylleibid (or leuconoid?). Skeleton of the chamber layer composed of the centrifugally directed rays of subgastral sagittal triradiates and the centripetally directed rays of subdermal pseudosagittal triradiates, which may be supplemented or partially replaced by confused triradiates. No colossal longitudinal oxea.

For illustrations of this genus see Dendy [1892 B].

In all the known species of *Vosmaeropsis* we find that the canal system has not developed beyond the sylleibid condition, and there can still be distinguished in the chamber layer very clear indications of an inarticulate tubar skeleton; in fact, the genus seems to have reached almost exactly the same level of evolution as *Megapogon* in the Grantiidae, when allowance is made for the different type of skeleton in the two families. This would at any rate seem to suggest that the family Heteropiidae is of comparatively recent origin, and that more complex forms, comparable to the higher types of the Grantiidae, have not yet made their appearance, unless, indeed, they have merely escaped observation.

We recognise the following species in this genus:—

#### SECTION A. With large oxea and microxea.

1. V. DEPRESSA *Dendy*.  
*Vosmaeropsis depressa* Dendy [1892 B].
2. V. MACERA *Carter*. Type species of the genus.  
*Heteropia macera* Carter [1885–1886].  
*Vosmaeropsis macera* Dendy [1892 B].
3. V. WILSONI *Dendy*.  
*Vosmaeropsis wilsoni* Dendy [1892 B].

SECTION B. With large, usually radially arranged oxea,  
but without microxea.

Although the author's description does not conform to the above diagnosis, we include Poléjaeff's *Leucilla connexiva* in this section of the genus, for the figures given by him show oxea present, though no reference is made to them in the text, and our own examination of the type specimen revealed the presence of occasional trichoxea.

4. V. *CONNEXIVA* Poléjaeff.  
*Leucilla connexiva* Poléjaeff [1883].
5. V. *CYATHUS* Verrill.  
*Leucandra cyathus* Verrill [1873].
6. V. *DENDYI* Row.  
*Vosmaeropsis dendyi* Row [1913 MS.].
7. V. *PRIMITIVA* Row.  
*Vosmaeropsis primitiva* Row [1913 MS.].
8. V. *SERICATUM* Ridley.  
*Aphroceras sericatum* Ridley [1884].

This species has been placed in *Vosmaeropsis* as a result of an examination of the type specimen made by us at the Natural History Department of the British Museum, which revealed the existence of typical subdermal pseudosagittal triradiates, though the author's original description does not mention them.

Genus 22. *GRANTILLA* Row [1909] (emend.).

*Diagnosis.* Canal system syconoid. Tubar skeleton (? always) inarticulate, composed of subdermal pseudosagittal triradiates and subgastral sagittal triradiates, supplemented by subdermal quadriradiates. No colossal longitudinal oxea.

For illustrations of this genus see Row [1909].

This genus was originally proposed by Row for two species, *G. quadriradiata* and *G. hastifera*, which were supposed to possess certain features that necessitated the provision of a new family, Grantillidae. We now consider, however, that the characters in question do not represent any fundamental peculiarities of structure, and we have therefore abandoned the family, as already stated in the Introduction.

One of the two species originally assigned to *Grantilla*, *G. quadriradiata*, however, presents an association of subdermal quadriradiates with subdermal pseudosagittal triradiates, which is not known in any other species of calcareous sponge, and we therefore retain the name *Grantilla* for this species with an emended diagnosis. The development of subdermal quadriradiates has evidently taken place repeatedly in the phylogeny of

the Calcarea. We have seen it already, for example, in *Leucetta*, *Leucaltis* and *Leucettusa*, and have not in those cases considered the presence of such spicules as of generic value. In *Grantilla*, however, they seem to assume more importance, and to take a larger share in the formation of the skeleton of the chamber layer. Nevertheless, had the genus not been already in existence, we should have hesitated to propose it on this character alone.

The only known species of the genus is :—

1. *G. QUADRIRADIATA* Row.

*Grantilla quadriradiata* Row [1909].

Family 8. GRANTIIDÆ Dendy [1892] (emend.).

*Diagnosis.* With a distinct dermal cortex and a proper cortical skeleton of tangential radiates, sometimes supplemented by, and occasionally replaced by, oxea. Flagellate chambers ranging from elongated and radially arranged to small, spherical and irregularly scattered. Skeleton of the chamber layer ranging from regularly articulate to irregularly scattered. Typically with subgastral sagittal radiates. No subdermal pseudosagittal triradiates. Subdermal quadri-radiates, if present, always associated with a chamber-layer skeleton containing confused triradiates. Nuclei of collared cells probably always apical.

It must frankly be admitted that the boundary line between the Sycettidæ and the Grantiidæ is by no means sharply defined. The great distinguishing feature is the presence in the latter of a distinct dermal cortex with its own proper skeleton. The development of such a cortex appears to have formed the determining condition for the further evolution of both the canal system and the skeleton, and it must therefore be regarded as of great systematic importance.

The first commencement of such a cortex is, however, so slight as to be almost indistinguishable from the mere pore-bearing dermal membrane of the most highly specialised Sycons. In *Grantia compressa* the cortex is so feebly developed that Dendy, in his early work [1892 B], included this species in the genus *Sycon*, laying more stress upon the presence of dermal tufts of oxea than we are now inclined to do in this connection. It appears to us that the line between *Sycon* and *Grantia*, and therefore between the Sycettidæ and Grantiidæ, must be drawn at the appearance of a dermal cortical skeleton of tangential radiates distinct from the skeleton of the radial chambers, and in accordance with these views *Grantia compressa* is excluded from the genus *Sycon*. Moreover, it must be pointed out that *G. compressa* is not the only member of this family in which dermal tufts of oxea occur, as they are present also in *Sycute dendyi* Kirk.

With the transition from the syconoid to the leuconoid type of canal system in this family, and the correlated replacement of the articulate tubar skeleton by irregularly scattered radiates, we get a close approach to the more advanced Leucascidæ, such as *Leucetta* and *Pericharax*, and we have here one of those cases of convergence which are so frequently met with amongst sponges, but we have already laid sufficient emphasis upon this point. Even in the genus *Leucandra*, however, subgastral sagittal tri-radiates are usually present, and when they are absent their absence must be regarded as secondary.

So far as our experience goes the nucleus of the collared cells is always apical in position in this family. We have been able to determine it in 17 species, as enumerated in an earlier section of this paper.

The family is a very large one, comprising no less than 23 out of the 51 genera of recent calcareous sponges which we recognise, and containing a great diversity of structural types within it. There are, however, very great difficulties in the way of dividing it into subfamilies, the chief of these being the fact that the possible methods of deriving the various genera from one another within the family are manifold, and it is impossible to determine satisfactorily which are the true lines upon which evolution has proceeded. We might, for example, place all those genera which have a syconoid canal system and colossal longitudinal oxea in the dermal cortex together in a subfamily *Uteinæ*; or we might separate the genus *Uteopsis* from the others, and unite it with *Achramorpha* and *Anamixilla* in a subfamily characterised by the reduction of the tubar skeleton to a single joint. But neither of these two possible subfamilies would seem to be very sharply defined, and moreover, the characters in question are not confined to members of the Grantiidæ. In short, we feel that in the present state of our knowledge it is impossible to decide which method of grouping would express most correctly the real affinities of the genera concerned. This is the case with almost all the possible methods of grouping the genera, and we have therefore decided not to attempt to split up the family, but merely to indicate the approximate relationships of the genera, so far as this is possible in a linear series, by the order in which we have arranged them,

Although it seems probable that the majority of the genera in this family are descended from the genus *Sycon*, yet it is quite possible that some of them may be descended independently from *Sycettia*, and therefore that the family may be of diphyletic origin.

We have changed the name of the family from Grantiidæ to Grantiidae in accordance with the usual practice of systematic zoologists.

## Genus 23. GRANTIA Fleming [1828] (emend.).

*Diagnosis.* Canal system syconoid. Colossal longitudinal oxea, if present, projecting from the surface. Tubar skeleton articulate, composed of radiate spicules, which may or may not be supplemented by oxea.

For illustrations of this genus see Dendy [1893 A].

It has been conclusively shown by Minchin [1896] that the type species of the genus *Grantia* is *G. compressa*, and that the name *Grantia* must always be given to the group of species associated with *G. compressa*. We have already pointed out that this species has a definite, though slight, dermal cortex, and that its true position is in the present family, and in fact, in the genus *Grantia* as defined by Dendy in 1892.

We may point out that *G. intermedia* Thacker stands alone in the genus, as far as is at present known, in the presence of apical rays on the tangential cortical radiates, and although we do not attach much importance to such spicules, we feel that their presence in this species indicates at any rate a possible starting point for the family Amphoriscidæ.

We recognise the following species as belonging to this genus:—

## SECTION A. With large, usually radially arranged oxea, but without microxea.

1. *G. ATLANTICA* Ridley.  
*Grantia atlantica* Ridley [1881].
2. *G. BREVIPILIS* Haeckel.  
*Sycandra capillosa* var. *brevipilis* Haeckel [1872].
3. *G. CANADENSIS* Lambe.  
*Grantia canadensis* Lambe [1896].
4. *G. CAPILLOSA* O. Schmidt.  
*Ute capillosa* O. Schmidt [1862].  
*Sycandra capillosa* Haeckel [1872].
5. *G. CHARTACEA* Jenkin.  
*Dermatreton chartaceum* Jenkin [1908 B].
6. *G. CLAVIGERA* O. Schmidt.  
*Sycinula clavigera* O. Schmidt [1870].  
*Sycandra clavigera* (*Sycandra compressa* var. *clavigera*)  
Haeckel [1872].
7. *G. COMOXENSIS* Lambe.  
*Grantia comoxensis* Lambe [1893].

8. G. COMPRESSA *Fabricius*. Type species of the genus.  
*Spongia compressa* Fabricius [1780].  
*Sycum lingua* Haeckel [1870], *fide* Haeckel [1872].  
*Sycarium rhopalodes* Haeckel [1870], *fide* Haeckel [1872].  
*Sycandra compressa* Haeckel [1872].  
*Sycon compressum* Dendy [1892 B].
9. G. FOLIACEA *Montagu*.  
*Spongia foliaceu* Montagu [1812].  
*Sycandra foliacea* (*Sycandra compressa* var. *foliacea*)  
Haeckel [1872].
10. G. GENUINA *Row*.  
*Grantia genuina* Row [1913 MS.].
11. G. GRACILIS *von Lendenfeld*.  
*Vosmaeria gracilis* von Lendenfeld [1885 B].
12. G. HODGSONI *Jenkin*.  
*Dermatreton hodysoni* Jenkin [1908 B].
13. G. INTERMEDIA *Thacker*.  
*Grantia intermedia* Thacker [1908].
14. G. LOBATA *Haeckel*.  
*Sycandra lobata* (*Sycandra compressa* var. *lobata*) Haeckel  
[1872].
15. G. LONGIPILIS *Haeckel*.  
*Sycandra capillosa* var. *longipilis* Haeckel [1872].
16. G. MONSTRUOSA *Breitfuss*.  
*Grantia monstruosa* Breitfuss [1898 B].
17. G. PENNIGERA *Haeckel*.  
*Sycandra pennigera* (*Sycandra compressa* var. *pennigera*)  
Haeckel [1872].
18. G. SCOTTI *Jenkin*.  
*Tenthrenodes scotti* Jenkin [1908 B].
19. G. TENUIS *Urban*.  
*Grantia tenuis* Urban [1908].
20. G. VOSMAERI *Dendy*.  
*Grantia vosmaeri* Dendy [1892 B].

#### SECTION B. Without any oxea.

21. G. ASCONOIDES *Breitfuss*.  
*Sycetta asconoides* Breitfuss [1896 B].

Our reasons for placing this species under *Grantia* rather than under *Sycetta* have been stated when discussing the latter genus.



22. *G. CUPULA* *Haeckel*.  
*Sycetta cupula* Haeckel [1872].
23. *G. INVENUSTA* *Lambe*.  
*Grantia invenusta* Lambe [1900 B].
24. *G. STROBILUS* *Haeckel*.  
*Sycetta strobilus* Haeckel [1872].

SECTION C. With large, usually radially arranged oxea,  
 and with microxea.

25. *G. ACULEATA* *Urban*.  
*Grantia aculeata* Urban [1908].
26. *G. EXTUSARTICULATA* *Carter*.  
*Hypograntia extusarticulata* Carter [1885-1886].  
*Grantia extusarticulata* Dendy [1892 B].
27. *G. INDICA* *Dendy*.  
*Grantia indica* Dendy [1912].
28. *G. MIRABILIS* *Fristedt*.  
*Ascandra mirabilis* Fristedt [1887].  
*Grantia mirabilis* Lundbeck [1909].
29. *G. TUBEROSA* *Poléjaeff*.  
*Grantia tuberosa* Poléjaeff [1883].

SECTION D. With microxea, but without large oxea.

30. *G. LÆVIGATA* *Haeckel*.  
*Sycortis laevigata* Haeckel [1872].  
*Sycortusa laevigata* von Lendenfeld [1885 B].
31. *G. PHILLIPSII* *Lambe*.  
*Grantia phillipsii* Lambe [1900 B].

The following are doubtfully assigned to this genus:—

32. *G. SINGULARIS* *Breitfuss*.  
*Sphenophorina singularis* Breitfuss [1898 B].

The genus *Sphenophorina* is discussed at some length in the list of rejected genera.

33. *G. URCEOLUS* *Müller*.  
*Spongia urceolus* Müller [1788-1796].

Stated by Johnston [1842] to be very probably a variety of  
*Grantia compressa*.

#### Genus 24. TEICHONOPSIS nov.

*Diagnosis.* Sponge consisting of a single stipitate person with enormously expanded gastral cavity and thin, much folded

wall, whose convoluted edge represents the oscular margin. Canal system syconoid. Tubar skeleton articulate. Without colossal longitudinal oxea.

For illustrations of this genus see Dendy [1891 B].

We propose this genus for the reception of the remarkable species *T. labyrinthica*, usually known as *Grantia labyrinthica*, which forms the subject of a special memoir by one of us, Dendy [1891 B]. We now consider that the very peculiar external form is of sufficient importance to justify generic separation. The species was originally placed by Carter in his genus *Teichonella*, on account of some superficial resemblance to his *T. prolifera*; but although the name *Teichonella* has now been universally abandoned even for *Leucetta* (*Teichonella*) *prolifera*, we do not consider ourselves justified in reviving it for *Grantia labyrinthica*, for Mr. Carter himself subsequently dissociated this species from *Teichonella* and placed it in the genus *Grantia* [1885-1886].

The only known species is:—

1. *T. LABYRINTHICA* Carter.

*Teichonella labyrinthica* Carter [1878].

*Grantia labyrinthica* Dendy [1891 B].

Genus 25. *GRANTIOPSIS* Dendy [1892 B].

*Diagnosis.* Canal system syconoid. Dermal cortex as thick as the chamber layer, with many layers of tangential triradiates. Tubar skeleton articulate, the proximal joint being composed of subgastral sagittal quadriradiates (? or triradiates), the other joints of sagittal triradiates practically reduced to the basal ray by suppression of the paired rays. Without colossal longitudinal oxea.

For illustrations of this genus see Dendy [1893 A] and Row [1913 MS.].

This genus was first proposed by Dendy [1892 B] for his *Grantiopsis cylindrica*, and was considered by him to be a sub-genus of *Grantia*. Jenkin [1908 B] placed it as a distinct genus in his family Staurorhaphidæ, on the ground that the subgastral spicules were "chiactines." As we cannot accept the chinct theory, we again transfer the genus to the Grantiida, but consider it sufficiently distinct from *Grantia* to deserve generic recognition.

We have recently discovered, as the result of our study of Mr. Carter's MS. illustrations, in the possession of one of us, that that author's "*Hypograntia infrequens* (incertæ sedis)" is undoubtedly a species of *Grantiopsis*, and the same species has recently turned up again in the collection made by the Hamburg

South-Western Australian Expedition of 1905. As neither Mr. Carter's *Hypograntia* nor the species *H. infrequens* were ever recognisably diagnosed, we do not consider it necessary to abandon the generic name *Grantiopsis*. The question will be more fully dealt with in the forthcoming report on the above-mentioned collection [Row 1913 MS.].

We recognise the following species in this genus:—

1. *G. CYLINDRICA* Dendy. Type species of the genus.  
*Grantiopsis cylindrica* Dendy [1892 B].
2. *G. INFREQUENS* Carter.  
*Hypograntia infrequens* Carter [1885–1886].  
*Grantiopsis infrequens* Row [1913 MS.].

#### Genus 26. SYCUTE nov.

*Diagnosis.* Canal system syconoid. Dermal cortex provided with colossal longitudinally arranged oxea. Tubar skeleton articulate. Distal ends of the flagellate chambers crowned with tufts of oxea lying between the colossal longitudinal oxea.

For illustrations of this genus see Kirk [1894].

This genus has been provided for Kirk's *Sycon dendyi*, a species which is curiously intermediate in character between *Sycon* and *Ute*, retaining the well-defined tufts of oxea which are characteristic of *Sycon* and at the same time possessing the colossal longitudinal oxea characteristic of *Ute*.

The only known species is:—

1. *S. DENDYI* Kirk.  
*Sycon dendyi* Kirk [1894].

#### Genus 27. UTE O. Schmidt [1862] (emend.).

*Diagnosis.* Canal system syconoid. Tubar skeleton articulate. Dermal cortex well developed, containing colossal longitudinal oxea. No tufts of oxea at the distal ends of the flagellate chambers.

For illustrations of this genus see Dendy [1893 A].

We allocate the following species to this genus:—

#### SECTION A. Without microxea.

1. *U. ENSATA* Bowerbank.  
*Grantia ensata* Bowerbank [1864–1882].  
*Sycandra glabra* var. *ensata* Haeckel [1872].

2. U. GLABRA O. Schmidt. Type species of the genus.  
*Ute glabra* O. Schmidt [1864].  
*Ute capillosa* J. E. Gray [1867], *vide* Haeckel [1872].  
*Sycandra glabra* Haeckel [1872].
3. U. RIGIDA Haeckel.  
*Sycandra glabra* var. *rigida* Haeckel [1872].
4. U. SYCONOIDES Carter.  
*Aphroceras syconoides* Carter [1885-1886].

## SECTION B. With microxea.

5. U. SPENCERI Dendy.  
*Ute spenceri* Dendy [1892 B].
6. U. SPICULOSA Dendy.  
*Ute spiculosa* Dendy [1892 B].

## Genus 28. SYNUTE Dendy [1892 A].

*Diagnosis.* Sponge consisting of many Ute-like individuals completely fused together, and invested with a common cortex containing colossal longitudinal oxea.

For illustrations of this genus see Dendy [1893 A].

This genus represents the highest known type of integration met with amongst syconoid sponges.

The only known species is :—

1. S. PULCHELLA Dendy.  
*Synute pulchella* Dendy [1892 A].  
*Synute pulchella* Row [1913 MS.].

## Genus 29. SYCODORUS Haeckel [1872] (emend.).

*Utella* Dendy [1892 B].

*Diagnosis.* Canal system syconoid. Tubar skeleton articulate. Gastral cortex with a layer of large longitudinally arranged oxea, but no oxea in the dermal cortex.

For illustrations of this genus see Haeckel [1872].

Dendy proposed the genus *Utella* in 1892 for the reception of Haeckel's *Sycandra hystrix*, and suggested that O. Schmidt's *Ute utriculus* might also be included in it. As we feel that the laws of priority necessitate our using Haeckel's subgeneric names, where possible, in preference to later ones, we propose to substitute *Sycodorus* for *Utella*, the species which precede *S. hystrix* in the subgenus in Haeckel's monograph having been assigned to earlier genera. For *Ute utriculus* we have retained the generic name *Sycandra*.

The only known species is:—

1. *S. HYSTRIX* *Haeckel*.  
*Sycandra hystrix* Haeckel [1872].

Genus 30. *ACHRAMORPHA* Jenkin [1908 B] (emend.).

*Diagnosis.* Canal system syconoid. Skeleton of the chamber layer reduced to the basal rays of the subgastral sagittal triradiates (which may become quadriradiates by the addition of an apical ray), with radial oxea lying between the chambers and projecting from the surface. No colossal longitudinal oxea.

For illustrations of this genus see Jenkin [1908 B]; and Breitfuss [1898 D] under *Ebnerella schulzei*.

This genus was proposed by Jenkin for the three species *glacialis*, *grandinis* and *nivalis*, which resemble one another closely, and which all possess the so-called chiactines of his supposed family Staurorhaphidae. The fact that another species, Breitfuss's *Ebnerella schulzei*, differs in no essential point except the absence of chiactines, affords strong evidence for our view that the latter are nothing but subgastral sagittal triradiates that have developed apical rays, and therefore not even of generic importance, since such spicules are known to occur in other Grantiidae. These species, however, form a well-defined group, and we accordingly retain the generic name *Achramorpha*, with an emended diagnosis based upon what we believe to be more important characters.

We assign the following species to the genus:—

SECTION A. With microxea.

1. *A. GLACIALIS* *Jenkin*.  
*Achramorpha glacialis* Jenkin [1908 B].
2. *A. GRANDINIS* *Jenkin*.  
*Achramorpha grandinis* Jenkin [1908 B].
3. *A. NIVALIS* *Jenkin*. Type species of the genus.  
*Achramorpha nivalis* Jenkin [1908 B].
4. *A. SCHULZEI* *Breitfuss*.  
*Ebnerella schulzei* Breitfuss [1896 A].

SECTION B. Without microxea.

5. *A. TRUNCATA* *Topsent*.  
*Grantia truncata* Topsent [1907].

## Genus 31. UTEOPSIS nov.

*Diagnosis.* Canal system syconoid. Tubar skeleton reduced to the basal rays of subgastral sagittal radiates, supplemented distally by radially arranged oxea. Dermal cortex well developed, and containing colossal longitudinal oxea.

For illustrations of this genus see Poléjaeff [1883].

We propose this genus for Poléjaeff's *Ute argentea*, which obviously differs widely from the other species of the genus *Ute*. The replacement of the distal portion of the tubar skeleton by oxea is a very unusual feature, and, from the analogy of *Grantiopsis*, we think it possible, but not probable, that these oxea are really radiates whose paired rays have been completely lost. It seems more probable that they are to be compared to the radial oxea of *Achramorpha*.

The "tubar" quadri-radiates referred to by Poléjaeff presumably belong to the exhalant canals of the chambers, and not to the chambers themselves.

The only known species of the genus is :—

1. U. ARGENTEA Poléjaeff.  
*Ute argentea* Poléjaeff [1883].

## Genus 32. ANAMIXILLA Poléjaeff [1883].

*Diagnosis.* Canal system syconoid. Tubar skeleton reduced to the outwardly directed basal rays of the subgastral sagittal radiates. Skeleton of the chamber layer otherwise consisting of large triradiate spicules, arranged without regard to the direction of the chambers. Dermal cortex well developed, but without colossal longitudinal oxea.

For illustrations of this genus see Poléjaeff [1883].

As Dendy has previously pointed out [1893 A], this genus may be looked upon as a *Grantia* in which the ordinary tubar skeleton has been almost entirely replaced by the invasion of large tri-radiates from the dermal cortex. Thus the genus is of interest as indicating one method by which the confused chamber-layer skeleton of *Leucandra* may have arisen.

The only known species is :—

1. A. TORRESI Poléjaeff.  
*Anamixilla torresi* Poléjaeff [1883].

## Genus 33. SYCYSSA Haeckel [1872].

*Diagnosis.* Canal system syconoid. Skeleton entirely composed of oxea. Dermal cortex well developed, but without colossal longitudinal oxea. Gastral cortex with a subgastral layer of oxea, arranged longitudinally.

For illustrations of this genus see Haeckel [1872].

This genus is highly remarkable for the complete suppression of the radiate spicules. An analogous condition is met with in *Ascyssa*, *Leucyssa*, *Trichogypsia* and *Kuarrhaphis*.

The only known species is :—

1. *S. HUXLEYI* Haeckel.

*Sycyssa huxleyi* Haeckel [1872].

## Genus 34. MEGAPOGON Jenkin [1908 B] (emend.).

*Diagnosis.* Canal system sylleibid or leuconoid. Skeleton of the chamber layer retaining clear traces of the original articulate character and not confused; composed chiefly of subgastral sagittal quadriradiates, with their apical rays projecting into the gastral cavity; with a few sagittal triradiates arranged as usual. No gastral skeleton of tangentially placed radiates, except round the osculum. No colossal longitudinal oxea.

For illustrations of this genus see Jenkin [1908 B].

Jenkin included in this genus five species, *M. cruciferus*, *M. villosus*, *M. raripilus*, *M. pollicaris* and *M. crispatus*, and placed it in the family Staurorrhaphidae on account of the presence of so-called chiactines. His figure of *M. villosus*, however, is alone sufficient to indicate that the "chiactines" are merely subgastral sagittal radiates which have developed apical rays, as in so many other cases, and we find it necessary to base the genus, which we believe to be a natural one, on other characters.

The absence of tangentially arranged gastral radiates, combined with the presence of the so-called "chiactines," might be used as an argument for the validity of the chiact theory, on the supposition that all the gastral tangential radiates had been converted into chiactines, but we must remember that in one species at any rate, *M. raripilus*, the so-called chiactines are associated with subgastral sagittal triradiates, which differ from them only in the absence of an apical ray, and there is no ground for supposing that the chiactines have any special significance. It is quite possible that all these subgastral sagittal spicules have been rotated into their present positions, as already pointed out in the Introduction, but this fact does not justify us in distinguishing

the chiacines as fundamentally different from other subgastral sagittal radiates.

*Megapogon villosus*, with its sylleibid canal system and almost syconoid skeleton, exhibits a very interesting stage in the evolution of the leuconoid type, and the same is perhaps true of *M. pollicaris*.

We place the following species in this genus:—

1. *M. CRISPATUS* Jenkin.  
*Megapogon crispatus* Jenkin [1908 B].
2. *M. CRUCIFERUS* Poléjaeff. Type species of the genus.  
*Leuconia crucifera* Poléjaeff [1883].
3. *M. POLLICARIS* Jenkin.  
*Megapogon pollicaris* Jenkin [1908 B].
4. *M. RARIPILUS* Jenkin.  
*Megapogon raripilus* Jenkin [1908 B].
5. *M. VILLOSUS* Jenkin.  
*Megapogon villosus* Jenkin [1908 B].

#### Genus 35. LEUCANDRA Haeckel [1872] (emend.).

*Diagnosis.* Sponge usually a single person, or a colony of such persons in which the component individuals are readily recognisable. Canal system leuconoid. Skeleton of the chamber layer more or less confused, but frequently with vestiges of an articulate tubar skeleton in the form of subgastral or other sagittal triradiates. Dermal skeleton of tangentially placed triradiates, which may sometimes develop an apical ray. Colossal longitudinally placed oxea, when occurring in the dermal cortex, never forming a smooth layer, but always projecting conspicuously from the surface.

For illustrations of this genus see Vosmaer [1880] and Dendy [1893 A].

The genus *Leucandra* as here defined is much more narrowly circumscribed than it was by Dendy previously [1892 B]. In fact Dendy's genus is here represented by no less than 10 genera, namely, *Leucandra*, *Baeria*, *Leucopsila*, *Aphroceras*, *Leucettaga*, *Lamontia* and *Eilhardia* in the family Grantiidae, and *Leucomallthe*, *Pericharax* and *Leucettusa* in other families, while certain species have been transferred to *Leucetta*. On the other hand, we include in the present genus certain species which possess subdermal quadriradiates, and which on that account were placed by Dendy in the genus *Leucilla*; for, as we had occasion to point out with regard to both *Leucetta* and *Grantia*,



we do not consider that the mere presence or absence of a fourth ray on a radiate spicule in the dermal cortex can be regarded as of generic import. We shall discuss the true characteristics of *Leucilla* when dealing with that genus.

The genus *Leucandra* as now defined may be regarded as derived from a *Grantia*-like ancestor by the conversion of the syconoid canal system into a leuconoid one, with the simultaneous replacement of the articulate tubar skeleton by an irregularly scattered skeleton of the chamber layer (compare *Anamixilla*). Indications of the syconoid ancestry can, however, frequently be detected in the skeleton (compare *Megapogon*), while as regards canal system such species as *L. australiensis* Carter and *L. infesta* sp. n. (*Leucilla intermedia* Row [1909]), which are of the so-called sylleibid type, form connecting links between *Grantia* and *Leucandra*.

We recognise the following species as belonging to this genus:—

SECTION A. With large, usually radially arranged oxea,  
but without microxea.

1. *L. ANANAS* Montagu.

*Spongia ananas* Montagu [1812].

*Spongia pulverulenta* Grant [1826], *vide* Haeckel [1872].

*Seypha ovata* S. F. Gray [1821], *vide* Haeckel [1872].

*Sycinula penicillata* O. Schmidt [1870], *vide* Haeckel [1872].

*Leucandra ananas* Haeckel [1872].

2. *L. ANGUINEA* Ridley.

*Leucortis anguinea* Ridley [1884].

3. *L. ANOMALA* Haeckel.

*Leucetia pandora* var. *anomala* Haeckel [1872].

4. *L. ARMATA* Urban.

*Leuconia armata* Urban [1908].

5. *L. ASPERA* O. Schmidt.

*Sycon asperum* O. Schmidt [1862].

? *Spongia panicea* Esper [?], *vide* Haeckel [1872].

? *Spongia inflata* Delle Chiaje [1828], *vide* Haeckel [1872].

*Leucandra aspera* Haeckel [1872].

6. *L. AUSTRALIENSIS* Carter.

*Leuconia fistulosa* var. *australiensis* Carter [1885–1886].

*Leucandra australiensis* Dendy [1892 B].

7. *L. CAMINUS* Haeckel.

*Dyssyconella caminus* Haeckel [1870].

*Leucandra caminus* Haeckel [1872].

8. L. CAPILLATA *Poléjueff*.  
*Leuconia multiformis* var. *capillata* Poléjueff [1883].
9. L. CIRRATA *Jenkin*.  
*Leucandra cirrata* Jenkin [1908 B].
10. L. CIRRHOSA *Urban*.  
*Leuconia cirrhosa* Urban [1908].
11. L. CLAVIFORMIS *Schuffner*.  
*Leucandra claviformis* Schuffner [1877].
12. L. COMPACTA *Carter*.  
*Leuconia compacta* Carter [1885-1886].
13. L. CRAMBESSA *Haeckel*.  
*Leucandra crambessa* Haeckel [1872].
14. L. CRUSTACEA *Haeckel*.  
*Leucaltis crustacea* Haeckel [1872].
15. L. CUMBERLANDENSIS *Lambe*.  
*Leucandra cumberlandensis* Lambe [1900 B].
16. L. DONNANI *Dendy*.  
*Leucandra donnani* Dendy [1905].
17. L. ECHINATA *Schuffner*.  
*Leucandra echinata* Schuffner [1877].  
*Leuconia echinata* Carter [1885-1886], *file* Dendy [1913].  
*Leucandra echinata* Dendy [1913].
18. L. EGEDII *O. Schmidt*. Type species of the genus.  
*Sycinula egedii* O. Schmidt [1870].  
*Leucandra egedii* Haeckel [1872].
19. L. FALCIGERA *Schuffner*.  
*Leucandra falcigera* Schuffner [1877].
20. L. FISTULOSA *Johnston*.  
*Grantia fistulosa* Johnston [1842].  
*Leucandra fistulosa* Haeckel [1872].
21. L. GEMMIPARA *Thacker*.  
*Leucandra gemmipara* Thacker [1908].
22. L. GOSSEI *Bowerbank*.  
*Leucogypsia gossei* Bowerbank [1864-1882].  
*Leucandra gossei* Haeckel [1872].
23. L. HIBERNA *Jenkin*.  
*Leucandra hiberna* Jenkin [1908 B].
24. L. HIRSUTA *Topsent*.  
*Leucandra hirsuta* Topsent [1907].

25. *L. HISPIDA* Carter.  
*Leuconia hispida* Carter [1885-1886].
26. *L. INFESTA*, *sp. n.*  
*Leucilla intermedia* Row [1909].  
The new name is given to this species as *intermedia* is already occupied.
27. *L. KERGUELENSIS* Urban.  
*Leucandra kerguelensis* Urban [1908].
28. *L. LENDENFELDI* Breitfuss.  
*Leuconia lendenfeldi* Breitfuss [1897].  
*Leucortis elegans* von Lendenfeld, MS., *fide* Breitfuss [1897].
29. *L. LUNULATA* Haeckel.  
*Leucandra lunulata* Haeckel [1872].
30. *L. MASATIERRÆ* Breitfuss.  
*Leuconia masatierræ* Breitfuss [1898 E].
31. *L. MEANDRINA* von Lendenfeld.  
*Leucandra meandrina* von Lendenfeld [1885 B].
32. *L. MINIMA* Row.  
*Leucandra minima* Row [1913 MS.].
33. *L. MULTIFORMIS* Poléjaeff.  
*Leuconia multiformis* Poléjaeff [1883].
34. *L. PHILLIPENSIS* Dendy.  
*Leucandra phillipensis* Dendy [1892 B].
35. *L. PALLIDA* Row.  
*Leucandra pallida* Row [1913 MS.].
36. *L. PULVINAR* Haeckel.  
*Sycolepis pulvinar* Haeckel [1870].  
*Mlea dohrnii* Michlucho-Maclay, MS., *fide* Haeckel [1872].  
*Leucortis pulvinar* Haeckel [1872].
37. *L. THULAKOMORPHA* Row.  
*Leucandra thulakomorpha* Row [1913 MS.].
38. *L. VAGINATA* von Lendenfeld.  
*Leucandra vaginata* von Lendenfeld [1885 B].
39. *L. VALIDA* Lambe.  
*Leucandra valida* Lambe [1900 B].
40. *L. VILLOSA* von Lendenfeld.  
*Leucandra villosa* von Lendenfeld [1885 B].

41. L. WASINENSIS *Jenkin*.

*Leucilla wasinensis* Jenkin [1908 A].

*Leucandra wasinensis* Dendy [1913].

SECTION B. With large, usually radially arranged oxea,  
and with microxea.

42. L. AMORPHA *Poléjaeff*.

*Leuconia multiformis* var. *amorpha* Poléjaeff [1883].

43. L. ANFRACTA *Urban*.

*Leuconia anfracta* Urban [1908].

44. L. APICALIS *Urban*.

*Leucandra apicalis* Urban [1905].

45. L. BALEARICA *Lackschewitsch*.

*Leuconia balearica* Lackschewitsch [1886].

46. L. BULBOSA *Hanitsch*.

*Leucandra bulbosa* Hanitsch [1895].

47. L. COIMBRÆ *Breitfuss*.

*Leuconia coimbræ* Breitfuss [1898 C].

48. L. CONICA *von Lendenfeld*.

*Leucandra conica* von Lendenfeld [1885 B].

49. L. CALLÆA *Haeckel*.

*Leucandra crambessa* var. *callæa* Haeckel [1872].

50. L. CROSSLANDI *Thacker*.

*Leucandra crosslandi* Thacker [1908].

51. L. CYLINDRICA *Fristedt*.

*Leucandra cylindrica* Fristedt [1887].

52. L. FERNANDENSIS *Breitfuss*.

*Leuconia fernandensis* Breitfuss [1898 E].

53. L. GLADIATOR *Dendy*.

*Leucandra gladiator* Dendy [1892 B].

54. L. HEATHII *Urban*.

*Leucandra heathii* Urban [1905].

55. L. JOUBINI *Topsent*.

*Leucandra joubini* Topsent [1907].

56. L. LORICATA *Poléjaeff*.

*Leuconia loricata* Poléjaeff [1883].

57. L. MINOR *Urban*.

*Leuconia minor* Urban [1908].

58. L. PLATEI *Breitfuss*.

*Leuconia platei* Breitfuss [1898 E].

59. L. PYRIFORMIS *Lambe*.  
*Leuconia pyriformis* Lambe [1893].
60. L. RODRIGUEZII *Lackschewitsch*.  
*Leuconia rodriguezii* Lackschewitsch [1886].
61. L. RUDIFERA *Poléjaeff*.  
*Leuconia rudifera* Poléjaeff [1883].  
*Leucandra rudifera* Thacker [1908].
62. L. SPISSA *Urban*.  
*Leuconia spissa* Urban [1908].
63. L. TAYLORI *Lambe*.  
*Leucandra taylori* Lambe [1900 A].
64. L. TYPICA *Poléjaeff*.  
*Leuconia typica* Poléjaeff [1883].
65. L. VITREA *Urban*.  
*Leuconia vitrea* Urban [1908].

## SECTION C. With microxea, but without large oxea.

66. L. JOHNSTONII *Carter*.  
*Grantia nivea* var., Johnston [1842].  
*Leuconia johnstonii* Carter [1871 B].  
*Leucandra johnstonii* Haeckel [1872].
67. L. LOBATA *Carter*.  
*Leuconia lobata* Carter [1885-1886].
68. L. MULTIFIDA *Carter*.  
*Leuconia multifida* Carter [1885-1886].
69. L. NIVEA *Grant*.  
*Spongia nivea* Grant [1825-1826].  
*Leucandra nivea* Haeckel [1872].
70. L. OVATA *Poléjaeff*.  
*Leuconia ovata* Poléjaeff [1883].
71. L. PRAVA *Breitfuss*.  
*Leuconia prava* Breitfuss [1898 C].

## SECTION D. Without oxea of any kind.

72. L. BATHYBIA *Haeckel*.  
*Dyssycum periminum* Haeckel [1870], *fide* Haeckel [1872].  
*Leucaltis bathybia* Haeckel [1872].  
*Grantia arabica* Michlucho-Maclay, MS., *fide* Haeckel [1873].

The earlier of Haeckel's names for this species, *periminum*, is a *nomen nudum*, as it never was accompanied by a diagnosis

73. L. BRUMALIS *Jenkin*.  
*Leucandra brumalis* Jenkin [1908 B].
74. L. CURVA *Schuffner*.  
*Leucandra curva* Schuffner [1877].
75. L. FRIGIDA *Jenkin*.  
*Leucandra frigida* Jenkin [1908 B].
76. L. GELATINOSA *Jenkin*.  
*Leucandra gelatinosa* Jenkin [1908 B].
77. L. HELENA *von Lendenfeld*.  
*Leucaltis helena* von Lendenfeld [1885 B].
78. L. IMPRESSA *Hanitsch*.  
*Leucaltis impressa* Hanitsch [1890].
79. L. INNOMINATA, *sp. n.*  
*Leucilla crosslandi* Row [1909].  
The new name is necessitated by the fact that the name  
*crosslandi* is already occupied in this genus.
80. L. INTERMEDIA *Haeckel*.  
*Leucetta pandora* var. *intermedia* Haeckel [1872].
81. L. LEVIS *Poléjaeff*.  
*Leuconia levis* Poléjaeff [1883].
82. L. NAUSICÆ *Schuffner*.  
*Leucaltis nausicæ* Schuffner [1877].
83. L. PANDORA *Haeckel*.  
*Leucetta pandora* Haeckel [1872].
84. L. PUMILA *Bowerbank*.  
*Leuconia pumila* Bowerbank [1864-1882].  
*Leucaltis pumila* Haeckel [1872].
85. L. SAGITTATA *Haeckel*.  
*Leucetta sagittata* Haeckel [1872].
86. L. SCHAUINSLANDI *Preiwisch*.  
*Leucetta schauinslandi* Preiwisch [1904].
87. L. TELUM *von Lendenfeld*.  
*Polejna telum* von Lendenfeld [1891].
88. L. VERDENSIS *Thacker*.  
*Leucandra verdensis* Thacker [1908].

The following species are doubtfully assigned to this genus :—

89. L. INFLATA *Delle Chiaje*.  
*Spongia inflata* Delle Chiaje [1828].  
Possibly identical with *Leucandra aspera*, *file* Haeckel [1872].

90. *L. PANICEA* Esper.

*Spongia panicea* Esper, *vide* Haeckel [1872].

Esper's original reference to this species has not been found by us, but Haeckel [1872] states that the species is possibly identical with *Leucandra aspera*.

Genus 36. *BAERIA* Michlucho-Maclay [1870] (emend.).

*Diagnosis.* Canal system leuconoid. Skeleton of the chamber layer composed almost exclusively of irregularly scattered colossal quadriradiates. Microxea present in large numbers, and of very characteristic form, being almost always pierced with a small hole towards one end.

For illustrations of this genus see Haeckel [1872].

The very characteristic "needle-eye" spicules of this genus are really triradiates, in which two of the rays are very much reduced and have come to lie approximately side by side, being actually fused at their distal ends. In this way we get a linear spicule very slightly swollen at one end, and in the centre of the swelling a small hole, the remnant of the space between the two originally separate rays. That this is the true explanation of these spicules was made abundantly clear from an examination by one of us (Row) of a microscopical preparation of the species preserved at Jena, for while most of the spicules were found to correspond exactly to the type described above, a few of them had the reduced rays not fused together but widely open, thus maintaining the triradiate condition. Exactly similar spicules occur in *Kuarrhaphis cretacea* (q. v.).

It may perhaps be pointed out here that these spicules indicate a possible way in which all the calcareous monaxon spicules may have originated. At any rate their occurrence adds probability to the presumption that all calcareous oxea have been derived from triradiates in some way or other.

The only known species of the genus is:—

1. *B. ochotensis* Michlucho-Maclay.

*Baeria ochotensis* Michlucho-Maclay [1870].

*Leucandra ochotensis* Haeckel [1872].

Genus 37. *LEUCOPSILA* nov.

*Diagnosis.* Canal system leuconoid. Skeleton of the chamber layer composed almost exclusively of irregularly scattered colossal quadriradiates. Gastral cortex well developed, but without any radiate spicules, the whole of the gastral skeleton being formed of a dense layer of microxea.

For illustrations of this genus see Haeckel [1872].

The very peculiar character of the skeleton of the gastral cortex seems to justify the erection of a new genus for O. Schmidt's *Leuconia styliifera*.

The only known species is:—

1. *L. STYLIFERA* O. Schmidt.

*Leuconia styliifera* O. Schmidt [1870].

*Leucandra styliifera* Haeckel [1872].

### Genus 38. *APHROCERAS* Gray [1858].

*Diagnosis.* Sponge usually a single person or a colony of such persons in which the component individuals are readily recognisable. Canal system syllebid or leuconoid. Skeleton of the chamber layer more or less confused, but frequently with vestiges of an articulate tubar skeleton in the form of subgastral or other sagittal radiates. Dermal skeleton of tangentially placed triradiates supplemented by colossal oxea placed longitudinally and not projecting from the surface sufficiently to render it hispid.

For illustrations of this genus see von Lendenfeld [1891], under *Vosmaeria corticata*.

The genus *Aphroceras* was originally proposed by Gray [1858] to receive a sponge from Hong-Kong, whose chief characteristics, at any rate from our point of view, were the leuconoid canal system and the colossal longitudinal oxea of the dermal cortex. Since then other species which combine these characters have been described, and, although recent authors have not seen fit to accept this genus, we feel that these species form a very natural group, and we consider that the characters distinguishing it are sufficiently well defined to render it possible to separate it from its nearest ally, *Leucandra*. In fact, almost the only species that presents any difficulty is Haeckel's *Leucandra crambessa* and its varieties, in which the colossal oxea are not arranged longitudinally, but lie scattered quite irregularly over the surface of the sponge. This condition is somewhat intermediate between that of some *Leucandras* and that of *Aphroceras*, and we prefer to place this species in the genus *Leucandra*.

It may be advisable to state that we do not consider *Aphroceras* to have been derived from *Ute* or a *Ute*-like form, but directly from an ancestral *Leucandra*.

We recognise the following species as belonging to this genus:—



## SECTION A. Without microxea.

1. A. *ALCICORNIS* Gray. Type species of the genus.  
*Aphroceras alcicornis* Gray [1858].  
*Cyathiscus actinia*, Haeckel [1870], *vide* Haeckel [1872].  
*Leucandra alcicornis* Haeckel [1872].
2. A. *CATAPHRACTA* Haeckel.  
*Leucandra cataphracta* Haeckel [1872].
3. A. *ELONGATA* Schuffner.  
*Leucandra elongata* Schuffner [1877].

## SECTION B. With microxea.

4. A. *CÆSPITOSA* Haeckel.  
*Leucandra alcicornis* var. *cæspitosa* Haeckel [1872].
5. A. *CLIARENSIS* Stephens.  
*Leucandra cliarensis* Stephens [1912].
6. A. *CORTICATA* von Lendenfeld.  
*Vosmaeria corticata* von Lendenfeld [1891].

Genus 39. *LEUCETTAGA* Haeckel [1872] (emend.).

*Diagnosis.* Canal system leuconoid. Skeleton almost entirely composed of a confused mass of triradiates, which are mostly irregular and which form the dermal cortical skeleton as well as the skeleton of the chamber layer. Gastral cavity traversed by numerous endogastric septa, which possess a special skeleton of their own in the form of minute radiates.

For illustrations of this genus see Haeckel [1872].

This genus is proposed for the reception of Haeckel's *Leucetta pandora* var. *loculifera*, which is the only known species. It affords an example amongst leuconoid Calcarea of that remarkable development of endogastric septa which occurs also in certain Leucosolenias (e. g. *L. wilsoni*) among the Homocœlidæ, in *Leucettusa* among the Leucaltidæ, and in *Sycandra* among the Sycettidæ. We have, however, only considered it necessary to attribute generic importance to this character when it is combined, as in the present instance, with the presence of an endogastric skeleton.

We have revived this name, which was applied by Haeckel to one of the subgenera of his *Leucetta*, for this genus.

The only known species is:—

1. *L. LOCULIFERA* Haeckel.  
*Leucetta pandora* var. *loculifera* Haeckel [1872].

Genus 40. *PARALEUCILLA* Dendy [1892 B].

*Diagnosis.* Canal system leuconoid. Skeleton of the chamber layer composed of confused triradiates. Subdermal cavities present, supported by an inner and an outer layer of quadriradiates, whose apical rays cross each other in opposite directions. Dermal cortex with tangentially placed triradiates, between which lie large, longitudinally placed oxea.

For illustrations of this genus see Haeckel [1872].

This genus was proposed by Dendy [1892 B] to receive Haeckel's *Leucandra cucumis*, but abandoned by him in 1893 on the ground that it was not sufficiently distinct from *Leucilla*. He also pointed out that Poléjaeff had previously proposed the name *Pericharax* for the same sponge. Further consideration has, however, convinced us that the dermal quadriradiates of *Leucandra cucumis* are not really comparable to the subdermal quadriradiates of *Leucilla* and other Amphoriscidæ, being related solely to the cortex and not to the chamber layer at all. We therefore transfer the species to the family Grantiidæ, with which it has much more in common than with any other family of Calcarea. We know nothing, however, of the position of the nucleus of the collared cells. The first mentioned species of *Pericharax*, on the other hand, is *P. carteri* Poléjaeff [1883, p. 19] which we have now shown to belong to the Leucascid-Leucaltid line of descent. We cannot therefore associate *Leucandra cucumis* with either *Leucilla* or *Pericharax*, and it therefore appears to us that as it is clearly distinguished from other Grantiidæ by the presence of subdermal cavities with a special skeleton, it is necessary to revive the genus *Paraleucilla* for its reception. Haeckel, it is true, placed his *Leucandra cucumis* in the subgenus "*Leucogypsa*," but Bowerbank's name "*Leucogypsia*," if revived at all, which we think very undesirable, would have to be reserved for *Leucandra*.

The only known species is:—

1. *P. CUCUMIS* Haeckel.

*Leucandra cucumis* Haeckel [1872].

*Paraleucilla cucumis* Dendy [1892 B].

Genus 41. *LAMONTIA* Kirk [1894].

*Diagnosis.* Sponge consisting of a single person with a specialised pore-zone below the terminal osculum. Canal system leuconoid. Skeleton of the chamber layer consisting of small scattered oxea. Dermal cortex with triradiates in addition to oxea. Gastral quadriradiates present.

For illustrations of this genus see Kirk [1894].

The only species of this curious genus is Kirk's *Lamontia zona* from New Zealand, which perhaps forms a transition from the genus *Leucandra* to the genus *Leucyssa*.

1. *L. zona* Kirk.

*Lamontia zona* Kirk [1894].

Genus 42. *LEUCYSSA* Haeckel [1872] (emend.).

*Diagnosis.* Canal system leuconoid. Skeleton entirely composed of smooth oxea.

For illustrations of this genus see Haeckel [1872].

We can only suppose that this genus, which has only been observed by Haeckel, owes its peculiar skeleton to the complete suppression of ancestral radiates.

The only known species is :—

1. *L. SPONGILLA* Haeckel.

*Leucyssa spongilla* Haeckel [1872].

Genus 43. *TRICHOGYPSIA* Carter [1871 B].

*Diagnosis.* Canal system leuconoid. Skeleton entirely composed of spined oxea.

For illustrations of this genus see Haeckel [1872].

In 1871 Carter proposed the genus *Trichogypsia* for his species *T. villosa*. In 1872, in "Die Kalkschwämme," Haeckel regarded this species as a variety of his *Leucyssa incrustans*, the specific name *incrustans* having been given by him *without description* in 1870 under the genus *Sycolepis*. The diagnosis of *Sycolepis* also contained no reference to the essential peculiarities of the species in question, and was subsequently abandoned by its author.

The name *Trichogypsia* has therefore priority in our opinion over both *Sycolepis* and *Leucyssa*, and we have retained it here for species which, like *T. villosa*, have spined oxea, while using Haeckel's name *Leucyssa* for those with smooth oxea.

We consider that Haeckel's variety *lichenoides*, which is the first variety of his *Leucyssa incrustans*, is specifically distinct from Carter's *Trichogypsia villosa*, and as the name *villosa* has priority over *incrustans*, we confine the latter to the form termed by Haeckel var. *lichenoides*.

We recognise the following species of this genus :—

1. *T. INCRUSTANS* Haeckel.

*Leucyssa incrustans* var. *lichenoides* Haeckel [1872].

2. *T. villosa* Carter. Type species of the genus.  
*Trichogypsia villosa* Carter [1871 B].  
*Leucyssa incrustans* var. *villosa* Haeckel [1872].

It is doubtful whether Haeckel's *Syccolepis incrustans* is really a synonym of *Trichogypsia villosa* or of *T. incrustans*.

#### Genus 44. KUARRHAPHIS nov.

*Diagnosis.* Canal system presumably leuconoid. Skeleton composed exclusively of perforated "needle-eye" spicules.

For illustrations of this genus see Haeckel [1872].

We propose this name for Haeckel's *Leucyssa cretacea*, which differs from all the other species included by him in the genus *Leucyssa* in the remarkable perforation of the "needle-eye" spicules. Spicules of practically identical form are found in the genus *Baeria*, and we must refer the reader to that genus for a discussion of their nature and origin. In *Baeria* they are still associated with triradiates and colossal quadriradiates. Whether *Kuarrhaphis* is to be regarded as derived from a *Baeria*-like ancestor by the complete suppression of the radiate spicules, or whether the remarkable "needle-eye" spicules have arisen independently in the two cases, it is impossible to decide.

The only known species is:—

1. *K. CRETACEA* Haeckel.  
*Leucyssa cretacea* Haeckel [1872].

#### Genus 45. EILHARDIA Poléjaffé [1883].

*Diagnosis.* Sponge calyciform, with pores on the inner and oscula on the outer surface of the cup. Canal system leuconoid. Skeleton of the chamber layer confused, composed of triradiates of various shapes and sizes, and of microxea. Cortex of inner surface with microxea and sagittal triradiates, cortex of the outer surface with large oxea and sagittal triradiates.

For illustrations of this genus see Poléjaffé [1883].

The only known species of the genus is Poléjaffé's *Eilhardia schulzei*, a highly remarkable sponge in many ways, the distribution of the pores and oscula being exactly the reverse of the usual condition in cup-shaped sponges, and indicating that the sponge cannot be regarded as a single leuconoid person with expanded osculum, in the same way as the calyciform *Pericharax periza*.

Although the genus *Eilhardia* was abandoned by Dendy [1892 B], we now consider that it is fully entitled to recognition.

The only known species is:—

1. *E. SCHULZEI* Poléjaeff.

*Eilhardia schulzei* Poléjaeff [1883].

Family 9. AMPHORISCIDÆ Dendy [1892 B] (emend.).

*Diagnosis.* Flagellate chambers ranging from elongated and radially arranged to small, spherical and irregularly scattered. With a distinct dermal cortex supported by a skeleton of tangentially placed radiates to which oxea may be added. Some or all of the dermal radiates with large apical rays, which project inwards through the chamber layer to a greater or less extent, and form the principal part of its skeleton. No articulate tubar skeleton, but sometimes, in the leuconoid forms, a confused skeleton of quadriradiates in the chamber layer. Nuclei of collared cells probably always apical.

The most conspicuous feature of this family lies in the large dermal or subdermal quadriradiates with centripetally directed apical rays. Such spicules may indeed be present in certain species of *Leucandra*, but in such cases they are always associated with a confused chamber-layer skeleton of scattered triradiates, which is never the case in the Amphoriscidæ. If there be a confused chamber-layer skeleton in this family it is found to be composed of quadriradiates, which presumably have been derived from the subdermal and subgastral quadriradiates themselves by immigration.

The evidence seems to indicate that *Leucandra* and *Leucilla*, though difficult to separate in practice, owe their resemblance largely to convergence, and that each has been independently evolved from some syconoid ancestor, in the one case directly from some such form as *Grantia*, in the other through some such form as *Amphoriscus*.

In some Amphoriscidæ large subgastral quadriradiates are present, and in others, or even in the same, subgastral sagittal triradiates (or quadriradiates) resembling the sagittal radiates of the first joint of an articulate tubar skeleton. Whether the centrifugally directed ray of the large subgastral quadriradiates is homologous with the basal ray of the subgastral sagittal triradiates, or whether it is an apical ray added to a tangential triradiate of the gastral cortex, is a question which we cannot decide without further evidence.

Genus 46. AMPHORISCUS Haeckel [1870] (emend.).

*Diagnosis.* Canal system syconoid. Without any special root-tuft of anchoring spicules.

For illustrations of this genus see Haeckel [1872] under *Sycaltis* and *Sycilla*, and Poléjaeff [1883].

We recognise the following species in this genus :—

SECTION A. Without oxea.

1. A. CHRYSALIS O. Schmidt.  
*Ute chrysalis* O. Schmidt [1864]. Type species of the genus.  
*Sycilla chrysalis* Haeckel [1872].
2. A. CYATHISCUS Haeckel.  
*Amphoriscus cyathiscus* Haeckel [1872].  
*Sycilla cyathiscus* Haeckel [1872].
3. A. CYLINDRUS Haeckel.  
*Sycilla cylindrus* Haeckel [1872].
4. A. KRYPTORAPHIS Urban.  
*Amphoriscus kryptoraphis* Urban [1908].
5. A. OVIPARUS Haeckel.  
*Sycaltis ovipara* Haeckel [1872].
6. A. SEMONI Breitfuss.  
*Amphoriscus semoni* Breitfuss [1896 C].
7. A. TESTIPARUS Haeckel.  
*Sycaltis testipara* Haeckel [1872].
8. A. URNA Haeckel.  
*Amphoriscus urna* Haeckel [1870].  
*Sycilla urna* Haeckel [1872].

SECTION B. With microxea, but without large oxea.

9. A. BUCCICHHI von Ebner.  
*Amphoriscus buccichii* von Ebner [1887].
10. A. ELONGATUS Poléjaeff.  
*Amphoriscus elongatus* Poléjaeff [1883].
11. A. GREGORII von Lendenfeld.  
*Ebnerella gregorii* von Lendenfeld [1891].
12. A. OBLATUS Row.  
*Amphoriscus oblatus* Row [1913 MS.].

Genus 47. *SYCULMIS* Haeckel [1872] (emend.).

*Diagnosis.* Canal system syconoid. With a root-tuft of oxea and anchoring quadriradiates.

For illustrations of this genus see Haeckel [1872].

This is a highly specialised genus of a single species, but had it not already been proposed by Haeckel, we should hardly have felt justified in distinguishing a special genus on the characters available.

The only known species is :—

1. *S. SYNAPTA* Haeckel.

*Syculmis synapta* Haeckel [1872].

Genus 48. *LEUCILLA* Haeckel 1872 (emend.).

*Diagnosis.* Canal system sylleibid or leuconoid. Skeleton of the chamber layer typically composed of the centripetally and centrifugally directed apical rays of subdermal and subgastral quadriradiates, but subgastral sagittal triradiates and confused chamber-layer quadriradiates may be present, while the subgastral quadriradiates may be absent.

For illustrations of this genus see Haeckel [1872] and Dendy [1893A].

The resemblance of this genus to some species of *Leucandra* has already been pointed out. It also resembles by convergence some species of the genus *Leucetta*, but may be distinguished by the fact that traces of syconoid ancestry are still to be met with in the skeleton (e. g., the presence in some species of subgastral sagittal triradiates), while the triradiates are not of the characteristic regular type occurring in the Leucascidae. The position of the nucleus of the collared cells, as determined in *Leucilla australiensis* and *L. princeps*, is, moreover, apical, instead of basal as in the Leucascidae.

We recognise the following species as belonging to this genus :—

## SECTION A. Without oxea.

1. *L. AMPHORA* Haeckel. Type species of the genus.

*Leucilla amphora* Haeckel [1872].

2. *L. AUSTRALIENSIS* Carter.

*Leuconia johnstoni* var. *australiensis* Carter [1885-1886].

*Leucilla australiensis* Dendy [1892 B].

3. *L. CAPSULA* *Haeckel*.  
*Lipostomella capsula* Haeckel [1870].  
*Leucilla capsula* Haeckel [1872].

SECTION B. With large radially arranged oxea or trichoxea, but without microxea.

4. *L. ECHINUS* *Haeckel*.  
*Leuculmis echinus* Haeckel [1872].
5. *L. OXEODRAGMIFERA* *Row*.  
*Leucilla oxeodragmifera* Row [1913 MS.].
6. *L. PRINCEPS* *Row*.  
*Leucilla princeps* Row [1913 MS.].
7. *L. PROTEUS* *Dendy*.  
*Leucilla proteus* Dendy [1913].
8. *L. UTER* *Poléjaeff*.  
*Leucilla uter* Poléjaeff [1883].

SECTION C. Without large oxea, but with microxea.

9. *L. NUTTINGI* *Urban*.  
*Rhabdodermella nuttingi* Urban [1902].
10. *L. SACCHARATA* *Haeckel*.  
*Leucandra saccharata* Haeckel [1872].

The following species apparently also belongs to this genus, but was very inadequately diagnosed:—

11. *L. LEUCONIDES* *Bidder*.  
*Sycaltis leuconides* Bidder [1891].

#### Family 10. LELAPIIDÆ nov.

*Dialytine* Kirkpatrick [1911 A].

*Diagnosis.* Canal system presumably always leuconoid. Skeleton of the chamber layer containing fibres or bundles of modified sagittal triradiates placed side by side, but not cemented together. Nuclei of collared cells (presumably always) apical.

This family appears to be a highly specialised offshoot from the leuconoid Grantiidæ. The presence in *Lelapia* of distinct sub-gastral sagittal triradiates and the apical position of the nuclei of the collared cells afford very strong evidence in support of this



view, and necessitate, as we have already pointed out, its wide separation from the other so-called Pharetronid sponges.

The presence of tuning-fork spicules in *Lelapia* cannot be taken as indicating close affinity with the latter, for, as is well known, such spicules occur in Haeckel's *Leucandra* (*Leucortis*) *pulvinar* and *L. (Leucetta)* *pandora*, while they are replaced in *Kebira*, the only other known genus of Lelapiidæ, by radiates in which the oral rays have been practically suppressed.

#### Genus 49. LELAPIA Gray [1867].

*Diagnosis.* Skeleton of the chamber layer composed of large scattered oxea and loose fibres of tuning-fork spicules. Dermal skeleton of tangential triradiates and microxea. Gastral skeleton of tangential triradiates and quadriradiates.

For illustrations of this genus see Dendy [1893 B].

This genus was originally based by Gray on figures published by Bowerbank of the characteristic tuning-fork spicules. Carter really first described the sponge, adopting Gray's name, *Lelapia australis*, for the species which he studied. There is, of course, no guarantee that Carter's species is either generically or specifically identical with that which furnished the spicules figured by Bowerbank. There is some probability, however, from the locality, and from the fact that the spicules are stated by Bowerbank to have been "loosely fasciculated," that the two species are really identical, and in any case the genus and species may conveniently be retained for the sponge described by Carter.

The only known species is :—

##### 1. *L. AUSTRALIS* Gray.

"*A new species of sponge*" Bowerbank [1858-1862].

*Lelapia australis* Gray [1867].

*Lelapia australis* Carter [1885-1886].

*Lelapia australis* Dendy [1893 B].

#### Genus 50. KEBIRA Row [1909].

*Diagnosis.* Skeleton of the chamber layer composed of large longitudinally arranged oxea, and of loose fibres of sagittal triradiates whose paired rays are vestigial. Dermal and gastral skeleton of tangential triradiates.

For illustrations of this genus see Row [1909].

The only known species is :—

##### 1. *K. UTEOIDES* Row.

*Kebira uteoides* Row [1909].

3. L. CAPSULA *Haeckel*.*Lipostomella capsula* Haeckel [1870].*Leucilla capsula* Haeckel [1872].

SECTION B. With large radially arranged oxea or trichoxea, but without microxea.

4. L. ECHINUS *Haeckel*.*Leuculmis echinus* Haeckel [1872].5. L. OXEODRAGMIFERA *Row*.*Leucilla oxeodragmifera* Row [1913 MS.].6. L. PRINCEPS *Row*.*Leucilla princeps* Row [1913 MS.].7. L. PROTEUS *Dendy*.*Leucilla proteus* Dendy [1913].8. L. UTER *Poléjaeff*.*Leucilla uter* Poléjaeff [1883].

SECTION C. Without large oxea, but with microxea.

9. L. NUTTINGI *Urban*.*Rhabdodermella nuttingi* Urban [1902].10. L. SACCHARATA *Haeckel*.*Leucandra saccharata* Haeckel [1872].

The following species apparently also belongs to this genus, but was very inadequately diagnosed:—

11. L. LEUCONIDES *Bidder*.*Sycaltis leuconides* Bidder [1891].

## Family 10. LELAPIIDÆ nov.

*Dialytinae* Kirkpatrick [1911 A].

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This family appears to be a highly specialised offshoot from the leuconoid Grantiidae. The presence in *Lelapia* of distinct sub-gastral sagittal triradiates and the apical position of the nuclei of the collared cells afford very strong evidence in support of this

view, and necessitate, as we have already pointed out, its wide separation from the other so-called Pharetronid sponges.

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#### Genus 49. LELAPIA Gray [1867].

*Diagnosis.* Skeleton of the chamber layer composed of large scattered oxea and loose fibres of tuning-fork spicules. Dermal skeleton of tangential triradiates and microxea. Gastral skeleton of tangential triradiates and quadriradiates.

For illustrations of this genus see Dendy [1893 B].

This genus was originally based by Gray on figures published by Bowerbank of the characteristic tuning-fork spicules. Carter really first described the sponge, adopting Gray's name, *Lelapia australis*, for the species which he studied. There is, of course, no guarantee that Carter's species is either generically or specifically identical with that which furnished the spicules figured by Bowerbank. There is some probability, however, from the locality, and from the fact that the spicules are stated by Bowerbank to have been "loosely fasciculated," that the two species are really identical, and in any case the genus and species may conveniently be retained for the sponge described by Carter.

The only known species is :—

##### 1. *L. AUSTRALIS* Gray.

"A new species of sponge" Bowerbank [1858-1862].

*Lelapia australis* Gray [1867].

*Lelapia australis* Carter [1885-1886].

*Lelapia australis* Dendy [1893 B].

#### Genus 50. KEBIRA Row [1909].

*Diagnosis.* Skeleton of the chamber layer composed of large longitudinally arranged oxea, and of loose fibres of sagittal triradiates whose paired rays are vestigial. Dermal and gastral skeleton of tangential triradiates.

For illustrations of this genus see Row [1909].

The only known species is :—

##### 1. *K. UTEOIDES* Row.

*Kebira uteoides* Row [1909].

# GENERA AND SPECIES "INCERTÆ SEDIS."

Genus 51. SYCALTIS Haeckel [1872] (emend.).

*Diagnosis?* Canal system syconoid(?). Skeleton of the chamber layer confused.

The sense in which we employ this genus is obviously quite different from that in which it was used by Haeckel, who based it upon the presence of triradiate and quadriradiate spicules and the absence of oxea. Most of the species assigned to it by him have been relegated to other genera, but his description of the undermentioned species appears to indicate that it possesses characteristics separating it widely from any syconoid sponge of normal structure, and therefore, although there seems to be some similarity between this sponge and *Leucascus*, we prefer to consider it as "*incertæ sedis*" rather than to assign any definite position to it in our classification. It may be related to *Anamixilla*.

The only known species is:—

1. S. PERFORATA Haeckel.

*Sycaltis perforata* Haeckel [1872].

The following species are so inadequately known as to render all attempts to identify them ineffectual:—

*Ute viridis* O. Schmidt [1868].

*Medon barbata* Duchassaing and Michelotti [1864].

*Medon imberbis* Duchassaing and Michelotti [1864].

The following species have been referred to without description:—

*Grantia striatula* Bowerbank MS., referred to by Bowerbank [1864–1882, vol. i. p. 233].

*Leucogypsia algoaensis* Bowerbank MS., referred to by Bowerbank [1864–1882, vol. i. p. 166].

*Ute papillosum* O. Schmidt, referred to by Gray [1867].

(We have not been able to discover any reference to a species of this name in any of Schmidt's papers, and think that Gray's reference is probably a misprint for *Ute capillosum* O. S.)

## LIST OF REJECTED GENERIC NAMES.

The following list includes all the generic names that have, so far as we are aware, been applied to calcareous sponges, but which we have not made use of in this paper. Many of them have been used in various senses by different authors, and in such cases all

the instances which are of systematic importance have been referred to, though the list of references is by no means complete. Under each genus the date and type-species are given, in order to simplify the work of determining the true names of genera in accordance with the laws of priority, should any of these names be revived for future use. We also give (in brackets) the name under which the type species will be found in the present paper.

*ALCYONCELLUM* Quoy et Gaimard [1833].

Type species, as regards calcareous sponges, *A. gelatinosum* de Blainville, (= *Sycon gelatinosum*).

The name *Alcyoncellum* was originally proposed by Quoy and Gaimard for certain hexactinellid sponges, but was subsequently used by de Blainville [1834-1837] to include *Sycon* (*Alcyoncellum*) *gelatinosum*. Gray [1867] has also used the name for a genus of calcareous sponges, and with the same type species. The name is now regarded as a synonym of both *Euplectella* and *Sycon*.

*AMPHORIDIUM* Haeckel [1870].

Type species *A. viridis* O Schmidt.

Schmidt's *Ute viridis* is absolutely unrecognisable, even generically.

*AMPHORULA* Haeckel [1870].

Type species *A. solida* O. Schmidt, (= *Leucandra solida*).

*ARTYNAS* Haeckel [1870].

Type species *A. compressus* Fabricius, (= *Grantia compressa*).

*ARTYNELLA* Haeckel [1870].

Type species *A. compressa* Fabricius, (= *Grantia compressa*).

*ARTYNES* Gray [1867].

Type species *A. compressa* Fabricius, (= *Grantia compressa*).

*ARTYNIUM* Haeckel [1870].

Type species *A. compressum* Fabricius, (= *Grantia compressa*).

*ARTYNOPHYLLUM* Haeckel [1870].

Type species *A. compressum* Fabricius, (= *Grantia compressa*).

*ASCALTIS* Haeckel [1872].

Type species *A. canariensis* Michlucho-Maclay, (= *Leucosolenia canariensis*).

*ASCANDRA* Haeckel [1872].

Type species *A. cordata* Haeckel, (= *Leucosolenia cordata*).

The name *Ascandra* has been used in almost exactly Haeckel's sense by several subsequent writers, notably von Lendenfeld, Breitfuss, Arnesen, and various systematists who have followed

the modification of Haeckel's original system proposed by von Lendenfeld in 1891. The name has also been used by Minchin [1896, 1900, &c.] in an entirely different sense for a genus whose type, and only, species was *A. falcata*, placed by us in the genus *Leucosolenia*. In the latter sense it is the equivalent of von Lendenfeld's *Homandra*.

*ASCETTA* Haeckel [1872].

Type species *A. primordialis* Haeckel, (= *Leucosolenia primordialis*).

As employed by Haeckel, this genus includes only species whose whole skeleton is composed of triradiates; von Lendenfeld, however, has used it [1891] to include all those ascon sponges which do not possess oxea.

*ASCILLA* Haeckel [1872].

Type species *A. gracilis* Haeckel, (= *Leucosolenia gracilis*).

*ASCOMETRA* Haeckel [1872].

Type species *A. primordiale* Haeckel, (= *Leucosolenia primordialis*).

The name *Ascometra* was used by Haeckel in the "artificial system" given at the end of his 'Monographie,' to replace the name *Thecometra* used for exactly the same group in his earlier 'Prodromus,' and for no apparent reason save nomenclatorial symmetry. He gave his new genus, however, a different type species.

*ASCORTIS* Haeckel [1872].

Type species *A. horrida* Haeckel, (= *Leucosolenia horrida*).

*ASCULMIS* Haeckel [1872].

Type species *A. armata* Haeckel, (= *Leucosolenia armata*).

*ASCURIS* Haeckel [1872].

Type species *A. arrecife* Haeckel, (= a variety of *Leucosolenia canariensis*).

*ASTROSCLERA* Lister [1900].

Type species *A. willeyana* Lister.

Although originally described as a member of the Calcarea, this sponge is now known to be an aberrant member of the Non-calcarea (*vide* Kirkpatrick [1912]).

*AULOPLEGMA* Haeckel [1870].

Type species *A. loculosum* Haeckel, (= *Leucosolenia loculosa*).

*AULORHIZA* Haeckel [1870].

Type species *A. intestinalis* Haeckel, (= *Leucosolenia lamareckii*).

*CALCISPONGIA de Blainville* [1834-1837].

Type species *C. compressa* Fabricius, (= *Grantia compressa*).

This genus was proposed by de Blainville in exactly the same sense as Fleming's *Grantia* [1828]. Since the latter genus takes priority, *Calcispungia* becomes merely a synonym of it.

*CLATHRINA Gray* [1867].

Type species *C. clathrus* O. Schmidt, (= *Leucosolenia clathrus*).

This genus has been employed by Minchin [1896, 1900] as the type genus of one of his families of homocel sponges. We have already (p. 718) given our reasons at length for not accepting his conclusions.

*CLYSTOLYNTHUS Haeckel* [1870].

Type species *C. vesicula* Haeckel, (= *Leucosolenia vesicula*).

*CÆNOSTOMELLA Haeckel* [1870].

Type species *C. caminus* Haeckel, (= *Leucandra caminus*).

*CÆNOSTOMIUM Haeckel* [1872].

Type species *C. crambessa* Haeckel, (= *Leucandra crambessa*).

*CÆNOSTOMUS Haeckel* [1872].

Type species *C. primigenius* Haeckel, (= *Leucetta primigenia*).

*CYATHISCUS Haeckel* [1870].

Type species *C. actinia* Haeckel, (= *Aphroceras alcicornis*).

*DERMATRETON Jenkin* [1908 B].

Type species *D. chartaceum* Jenkin, (= *Grantia chartacea*).

This genus was proposed by Jenkin for certain species of the family Grantiidae, which possess "linked" chambers. We do not consider that this character is of generic rank, and we have therefore included both these species in the genus *Grantia*.

*DJEDDEA Michlucho-Maclay* MS. (*vide* Haeckel [1872]).

Type species *D. violacea* Michlucho-Maclay MS., *vide* Haeckel [1872], (= *Grantessa stauridea*).

The generic name *Djeddea* is quoted by Haeckel in the synonymy list attached to his *Sycetta stauridea*. This seems to be the only authority for the name.

*DUNSTERVILLIA Bowerbank* [1845].

Type species *D. elegans* Bowerbank, (= *Sycon elegans*).

Bowerbank's genus was adopted by Haeckel as one of the genera of his "artificial" system, but no other author seems to have made use of it save Gray. It is now considered to be merely a synonym of *Sycon*.

*DYSSYCARIUM* Haeckel [1872].

Type species *D. egedii* O. Schmidt, (= *Leucandra egedii*).

In proposing this genus Haeckel states that it is equivalent to O. Schmidt's *Sycinula*. Both these are considered by us to be synonyms of *Leucandra*, but the question is discussed in more detail under *Sycinula*.

*DYSSYCONELLA* Haeckel [1870].

Type species *D. pumila* Bowerbank, (= *Leucandra pumila*).

*DYSSYCON* Haeckel [1870].

Type species *D. fistulosum* Johnston, (= *Leucandra fistulosa*).

*DYSSYCUS* Haeckel [1872].

Type species *D. primigenius* Haeckel, (= *Leucetta primigenia*).

A genus of the artificial system, identical with *Dyssycum* of the 'Prodromus' of 1870. There does not seem to be any reason for the change of spelling, but such changes, and sometimes more radical ones, were made by Haeckel in several cases in his later work.

*EBNERELLA* von Lendenfeld [1891].

Type species *E. buccichii* von Ebner, (= *Amphoriscus buccichii*).

*GUANCHA* Michlucho-Maclay [1868].

Type species *G. blanca* Michlucho-Maclay, (= *Leucosolenia blanca*).

*HETEROPEGMA* Poléjaeff [1883].

Type species *H. nodus-gordii* Poléjaeff, (= *Leucaltis clathria*).

As we have shown when discussing *Leucaltis*, Poléjaeff's name is merely a synonym of the latter.

*HOMANDRA* von Lendenfeld [1891].

Type species *H. falcata* von Lendenfeld, (= *Leucosolenia falcata*).

This genus is the equivalent of *Ascandra* in Minchin's sense [1896, 1900, &c.], but must not be confused with *Ascandra* in the original sense of Haeckel. The latter genus was used by von Lendenfeld in almost exactly Haeckel's sense, so that, since he considered *A. falcata* to be worthy of generic separation, a new name became necessary. At a later date Minchin revised the classification of the homocœl sponges, and relegated the name *Ascandra* to *A. falcata*, so that the name *Homandra* was rendered unnecessary. (See, for details, Minchin [1896, 1897].) We have given above (p. 720) our reasons for considering the separation of *L. falcata* from the genus *Leucosolenia* to be inadvisable.



*HOMODERMA von Lendenfeld* [1885 A].

Type species *H. sycandra* von Lendenfeld, (= *Sycon sycandra*).

This genus was proposed for a somewhat aberrant *Sycon*, and was made by its author the only genus of a new family of Ascones, the Homoderinidæ. The question has been dealt with to some extent above (p. 716), and is fully investigated in Row's report on the Calcareous of the Hamburg South-Western Australian Expedition of 1905 (see Row [1913 MS.]).

*HOMETTA von Lendenfeld* [1891].

A genus proposed by von Lendenfeld on hypothetical characters, and without any species.

*HYPODICTYON Jenkin* [1908 B].

Type species *H. longstaffi* Jenkin, (= *Sycon longstaffi*).

This genus was erected by Jenkin for the above species, and placed by him in his supposed family Chiphoridae, on account of the presence of chiaetines, being separated from *Streptoconus* on account of the "linking" of the chambers. Neither of these characters is considered by us as of generic value.

*HYPOGRANTIA Carter* [1885-1886].

Type species *H. infrequens* Carter, (= *Grantiopsis infrequens*).

This genus was proposed by Carter for several species of diverse nature, and the diagnosis was extremely unsatisfactory. Further, the first (*i. e.* type) species was said by its author to be "incertæ sedis." Under these circumstances we do not feel that we can allocate the name to any of our genera.

*LEUCKARTEA Michlucho-Maclay* MS., *fide* Haeckel [1872].

Type species *L. natalensis* Michlucho-Maclay MS., *fide* Haeckel [1872], (= *Sycon ramosum*).

The only warranty for this name seems to be that it is included in the synonymy list attached to Haeckel's *Sycandra ramosa* as a MS. name of Michlucho-Maclay's.

*LEUCOGYPSIA Bowerbank* [1864-1882].

Type species *L. gossei* Bowerbank, (= *Leucandra gossei*).

One of the four genera of Calcareous sponges proposed by Bowerbank in his 'Monograph of British Sponges.' It is now usually considered to be a synonym of *Leucandra*, and although perhaps it has right of priority over the latter, yet we feel that the name *Leucandra* is so well known that it should be preserved.

*LEUCOMETRA Haeckel* [1872].

Type species *L. primigenia* Haeckel, (= *Leucetta primigenia*).

*LEUCONIA Grant* [1841].

A genus proposed by Grant and used by many subsequent authors very nearly in the sense in which we use *Leucandra*.

(e.g. Carter, Poléjaeff, Urban, etc.), but as shewn by Vosmaer [1887] and Dendy [1893 A], the name is not valid, as it had been previously applied to a genus of MOLLUSCA.

LEUCOPSIS von Lendenfeld [1885 B].

Type species *L. pedunculata* von Lendenfeld, (= *Leucosolenia pedunculata*).

This species was supposed by von Lendenfeld to be a transition form between Haeckel's Ascones and Leucones, but it seems to us that the structure described is far more probably that of a Clathrinoid *Leucosolenia* provided with a stalk.

LEUCORTIS Haeckel [1872].

Type species *L. pulvinar* Haeckel, (= *Leucandra pulvinar*).

LEUCULMIS Haeckel [1872].

Type species *L. echinus* Haeckel, (= *Leucilla echinus*).

LIPOSTOMELLA Haeckel [1870].

Type species *L. clausa* Haeckel, (= *Leucetta primigenia*).

MEDON Duchassaing et Michelotti [1864].

Type species *M. barbata* Duchassaing et Michelotti (*incertae sedis*).

A genus comprising two species, both of which are quite unrecognisable, and may even not be calcareous sponges.

MERLIA Kirkpatrick [1908].

Type species *M. normani* Kirkpatrick.

This sponge was originally described as a member of the family Pharetronidae, but recently Kirkpatrick has shown that its true place is among the Non-calcareous.

MLEA Michlucho-Maclay MS., *vide* Haeckel [1872].

Type species *M. dohrnii* Michlucho-Maclay MS., *vide* Haeckel [1872], (= *Leucandra pulvinar*).

The only authority for this name seems to be Haeckel, who published several MS. names in the synonymy lists attached to various species in his Monograph.

MÖBIUSISPONGIA Duncan [1880].

Type species *M. parasitica* Duncan.

An organism originally described as a parasitic calcareous sponge, but it seems very doubtful whether it belongs to the sponges at all. We certainly do not feel inclined to recognise it, without further evidence, as a member of the Calcareous.

NARDOA O. Schmidt [1862].

Type species *N. reticulum* O. Schmidt, (= *Leucosolenia reticulum*).

Minchin [1896] has shown that this name was previously

used for a genus of ASTEROIDEA, and is therefore permanently unavailable.

NARDOMA *Haeckel* [1872].

Type species *N. nitida* Haeckel, (= *Leucosolenia nitida*).

NARDOPSIS *Haeckel* [1870].

Type species *N. gracilis* Haeckel, (= *Leucosolenia gracilis*).

NARDORUS *Haeckel* [1872].

Type species *N. primordialis* Haeckel, (= *Leucosolenia primordialis*).

OLYNTHELLA *Haeckel* [1872].

Type species *O. coriacea* Montagu, (= *Leucosolenia coriacea*).

OLYNTHIUM *Haeckel* [1870].

Type species *O. nitidum* Haeckel, (= *Leucosolenia nitida*).

OLYNTHUS *Haeckel* [1870].

Type species *O. simplex* Haeckel, (= *Leucosolenia primordialis*).

This name, as an actual generic name, is considered by us to be merely a synonym of *Leucosolenia*, but we may point out that its author proposed it for what he considered to be the most primitive adult sponge known, and, although we now believe that he probably erred in considering specimens of this form to be adult, yet the name is still retained for a hypothetical genus of ancestral Calcareia, and for an early stage in the ontogeny of the individual. Even should adult *Olyntus*-forms occur, however, we do not consider that they would be generically separable from *Leucosolenia*.

POLEJNA *von Lendenfeld* [1891].

Type species *P. uter* Poléjaeff, (= *Leucilla uter*).

One of the genera based by von Lendenfeld on the presence of a sylleibid canal system, a character which we do not consider of generic importance.

PROSYCUM *Haeckel* [1870].

Type species *P. simplicissimum* Haeckel, (= *Leucosolenia primordialis*).

RHABDODERMELLA *Urban* [1902].

Type species *R. nuttingi* Urban, (= *Leucilla nuttingi*).

SCYPHA *S. F. Gray* [1821].

Type species *S. coronata* Ellis and Solander, (= *Sycon coronatum*).

The genus *Scypha* actually has priority over Risso's *Sycon*, but

the latter has so long been in general use that it seems desirable to retain it. Moreover, the earlier name was proposed by a botanist for organisms which he regarded as plants, and the generic diagnosis was hopelessly erroneous and misleading.

*SOLENIIDIUM* *Haeckel* [1872].

Type species *S. nitidum* Haeckel, (= *Leucosolenia nitida*).

*SOLENISCUS* *Haeckel* [1870].

Type species *S. loculosus* Haeckel, (= *Leucosolenia loculosa*).

*SOLENULA* *Haeckel* [1872].

Type species *S. coriacea* Montagu, (= *Leucosolenia coriacea*).

*SPHENOPHORINA* *Breitfuss* [1898 B].

Type species *S. singularis* Breitfuss, (= *Grantia* ? *singularis*).

This name was originally proposed for a sponge showing certain apparently great peculiarities in its skeletal structure and in the form of its spicules. Possibly, if the structure described really represents that of the sponge, it merits a distinct genus, but the fact that only a fragment was found, and that that fragment had been preserved in spirit for no less than 33 years before it was examined by Breitfuss, led us to doubt whether there had not been some corrosion of the spicules during that time. This opinion was supported by an examination of type slides which one of us (Row) was able to make when in Berlin recently, for the appearance of the specimens is just what might be produced by the very slow eating away of the terminal portions of the spicules by very dilute acid. Under these circumstances we feel that the genus had better be abandoned for the present, at any rate until further material of the species assigned to it has been obtained, and we have accordingly placed the only described species provisionally in the genus *Grantia*.

*SPHENOPHORUS* *Breitfuss* [1898 B].

Type species *S. singularis* Breitfuss, (= *Grantia* ? *singularis*).

An earlier name for the previous genus, abandoned by its author as being preoccupied.

*SPONGIA* *Linnaeus* [1758-1759].

The name under which the earlier known species of Calcareous sponges were, in common with non-calcareous forms, described, but now entirely abandoned.

*STREPTOCONUS* *Jenkin* [1908 B].

Type species *S. australis* Jenkin, (= *Sycon australe*).

One of the genera of Jenkin's family Chiphoridae, which has been abandoned by us for reasons given above.

SYCANTHA von Lendenfeld [1891].

Type species *S. tenella* von Lendenfeld, (= *Sycon tenellum*).

This genus was retained by Dendy [1892 B], but although the species placed in it by von Lendenfeld is certainly aberrant, we agree with Jenkin [1908 B] that it does not merit generic recognition.

SYCARIUM Haeckel [1870].

Type species *S. ampulla* Haeckel, (= *Sycon ampulla*).

SYCIDIUM Haeckel [1870].

Type species *S. gelatinosum* de Blainville, (= *Sycon gelatinosum*).

SYCILLA Haeckel [1872].

Type species *S. cyathiscus* Haeckel, (= *Amphoriscus cyathiscus*).

SYCINULA O. Schmidt [1868].

Type species *S. aspera* O. Schmidt, (= *Leucandra aspera*).

This name, strictly speaking, may have priority over *Leucandra*, but it was only mentioned casually by Schmidt, without diagnosis, although he indicated *S. aspera* as type of the genus, and it has never been accepted, except by Haeckel for one of his "artificial" genera, whereas *Leucandra* has come into fairly general use. And further, if the name *Leucandra* were changed, it apparently should be changed to *Leucogypsia* rather than to *Sycinula*.

SYCOCYSTIS Haeckel [1870].

Type species *S. oviformis* Haeckel, (= *Sycon ciliatum*).

SYCODENDRUM Haeckel [1870].

Type species *S. ramosum* Haeckel, (= *Sycon ramosum*).

SYCOLEPIS Haeckel [1870].

Type species *S. incrustans* Haeckel, (= either *Trichogypsia incrustans* or *T. villosa*).

SYCOMETRA Haeckel [1870].

Type species *S. compressum* Fabricius, (= *Grantia compressa*).

SYCONELLA O. Schmidt [1868].

Type species *S. quadrangulata* O. Schmidt, (= *Sycon quadrangulatum*).

SYCOPHYLLUM Haeckel [1870].

Type species *S. lobatum* Haeckel, (= *Grantia lobata*).

SYCORRHIZA Haeckel [1870].

Type species *S. coriacea* Montagu, (= *Leucosolenia coriacea*).

SYCORTIS Haeckel [1872].

Type species *S. laevigata* Haeckel, (= *Grantia laevigata*).

*SYCORTUSA* Haeckel [1872].

Type species *S. laevigata* Haeckel, (= *Grantia laevigata*).

One of the subgenera into which Haeckel divided his genus *Sycortis*, raised by von Lendenfeld [1891] to generic rank.

*SYCOTHAMNUS* Haeckel [1870].

Type species *S. fruticosus* Haeckel, (= *Leucetta primigenia*).

*SYCUM* Haeckel [1870].

Type species *S. ciliatum* Fabricius, (= *Sycon ciliatum*).

A modification of Risso's generic name *Sycon* for which there does not seem to have been any adequate reason.

*SYCURUS* Haeckel [1872].

Type species *S. primitivus* Haeckel, (= *Sycetta primitiva*).

*TARROMA* Haeckel [1870].

Type species *T. canariense* Michlucho-Maclay, (= *Leucosolenia canariensis*).

*TARROPSIS* Haeckel [1872].

Type species *T. coriacea* Montagu, (= *Leucosolenia coriacea*).

*TARRUS* Haeckel [1870].

Type species *T. densus* Haeckel, (= *Leucosolenia densa*).

*TEICHONELLA* Carter [1878].

Type species *T. prolifera* Carter, (= *Leucetta prolifera*).

A genus proposed by Carter for two species, whose slight similarity of external form misled him into thus associating them. One of these has now been placed by us in the genus *Leucetta*, the other is the type of our genus *Teichonopsis*. For a criticism of the genus *Teichonella* and its species see Dendy [1891 B].

*TENTHRENODES* Jenkin [1908 B].

Type species *T. antarcticus* Jenkin, (= *Sycon antarcticum*).

For a discussion of this genus and its species see under *Sycon* (p. 744).

*THECOMETRA* Haeckel [1870].

Type species *T. loculosa* Haeckel, (= *Leucosolenia loculosa*).

*UTELLA* Dendy [1892 B].

Type species *U. hystrix* Haeckel, (= *Sycodorus hystrix*).

We have found it necessary to substitute Haeckel's name *Sycodorus* for the above.

*VOSMAERIA* von Lendenfeld [1885 B].

Type species *V. gracilis* von Lendenfeld, (= *Grantia gracilis*).

One of the genera based by von Lendenfeld on the presence of

a "syllleibid" canal system, a character which we do not consider to be of generic importance.

*WAGNERELLA Merejkowski* [1878]<sup>1</sup>

Type species *W. borealis* Merejkowski.

An organism originally described as a calcareous sponge, but shewn by Mayer [1879] to be a Heliozoan.

In addition to the above, an enormous number of subgeneric names, both "artificial" and "natural," were proposed by Haeckel in his two works on the group, but the list is sufficiently swollen out with discarded generic names, without including subgeneric ones also.

#### PHYLOGENY OF THE CALCAREA.

Our views as to the phylogeny of the Calcarea, elaborated in the foregoing pages, may now be summarised as follows, and illustrated by the accompanying phylogenetic tree. This tree differs in certain important respects from that published by one of us twenty years ago [Dendy, 1893 A], which is only to be expected when we consider the great advances made in our knowledge of the group in the interval. All the families of the earlier scheme, and the general ideas of their relationships to one another in the main lines of descent, are, however, retained with but little alteration, but we recognise now four additional families of recent Calcarea, the Leucaltidae, the Minchinellidae, the Murrayonidae and the Lelapiidae, while several genera have had to be transferred from one family to another.

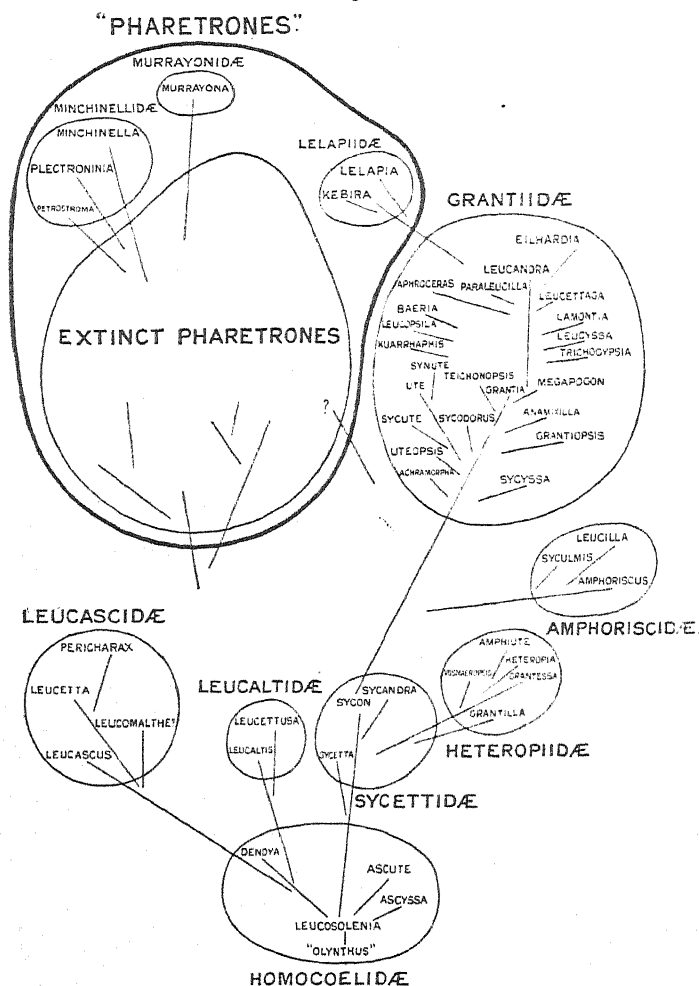
One of the most important advances in the classification of the group was made by Minchin [1896], in his demonstration that even among the homocel sponges two types of collared cells are met with, with apical and basal nuclei respectively; a suggestion which was followed up by Bidder [1898], who, it will be remembered, proposed to divide, not only the Calcarea, but the whole of the sponges into BASINUCLEATA and APINUCLEATA accordingly, or, confining the suggestion to the Calcarea, to divide these into CALCARONEA with apical, and CALCINEA with basal, nuclei.

We think it quite likely that the latter of these two suggestions will ultimately prove to be thoroughly sound. With regard to the former, however, we consider it highly probable that several distinct types of collared cells will be shewn to exist in the non-calcareous sponges, though as yet we have very little information on this point.

Continuing the observations of Minchin, we find that in the

genus *Leucosolenia*, which admittedly stands at the bottom of the line of evolution of the Calcarea, both types of collared cells exist, but apparently not side by side in the same species; and we find further, that the two principal lines of descent, which

Text-fig. 133.



### PHYLOGENY OF CALCAREOUS SPONGES.

appear, on quite other grounds, to have sprung from the homocel sponges, are characterised respectively by the two types of collared cells. It is interesting to note that these two main lines



of descent were clearly indicated twenty years ago, as represented by the Leucascidae and Sycettidae respectively.

It must, of course, be remembered that the real difference between the two types of collared cells concerns, as Minchin has shewn [1909], the relation of the flagellum, with its basal granule, to the nucleus. This relation has, of course, only been determined in a very few cases. In *Leucosolenia coriacea*, for example, the basal granule is situated at the apex of the cell and the nucleus at the base, while in *L. complicata* the flagellum appears to spring from the nucleus itself, which is apically situated. There can be no doubt that the actual position of the nucleus itself in the collared cell may vary temporarily under certain conditions, but in good spirit-preserved material it appears always to settle down into a characteristic position, which is either basal or apical, and which may be determined without resort to special methods of cytological investigation. We do not wish to lay undue stress upon this character at present, and we should not venture to use it were it not associated with other distinctive features, but we have been surprised, in view of our former opinion as to the systematic value of such a character, to find how constant the position of the nucleus is in the two lines of descent indicated. This will be sufficiently evident from reference to the table given in the Introduction.

We have in vain attempted to split up the unwieldy genus *Leucosolenia* into smaller groups. The utmost we have been able to do has been to isolate from the main body of species three well-marked types, *Ascyssa*, *Ascute* and *Dendya*. We do not consider that Minchin's proposal to divide the homocœl sponges into two families, Leucosoleniidae and Clathrinidae, is at all practicable in the present state of our knowledge, and if it be true, as he himself has pointed out [1909], following Goldschmidt, that the two types of relation of flagellum to collared cell may occur in the same genus of Protozoa (*Mastigina*), we see no reason for supposing that both may not occur in the genus *Leucosolenia*. According to our view, this is a large and heterogeneous group of primitive forms all closely related to one another and merging into one another to a large extent, from which the two lines of descent referred to have led the way to the evolution of the higher Calcarea.

We will take the *Dendya*, or Leucascid-Leucaltid, line first, in which the nucleus of the collared cells is basal. The starting point of this line seems to have been from some form closely related to *Dendya*. The radiate arrangement of the colony in this genus formerly misled Dendy [1893 A.] into regarding it as on the line of evolution of the Sycettidae, but there are several strong arguments against this view. The radiate arrangement appears to be but a modification of a reticulate "Clathrinid" character, and actual open anastomoses may occur between the radial tubes, which, in spite of what has been said by more than

one author, appears rarely if ever to be the case in true Sycettidæ or their descendants. To this must be added the primitive type of skeleton, composed exclusively of equiangular radiates, which do not exhibit the characteristic arrangement met with in the syconoid sponges, with their differentiated gastral cortex and articulate tubar skeleton. In this connection we may especially note the absence of subgastral sagittal triradiates (or quadri-radiates), which form such a constant feature of the Sycettidæ and their derivatives.

The *Dendya* line seems to have given off two branches, represented by the Leucascidæ and Leucaltidæ respectively. The Leucascidæ are undoubtedly the more primitive of the two. The genus *Leucascus* itself, indeed, might very easily be mistaken for a homocæl sponge were it not for the presence of a distinct and independent pore-bearing dermal membrane; it retains the elongated, branched, and more or less radially arranged flagellate chambers of its *Dendya*-like ancestors. Within the family evolution has led to the development of a more highly differentiated dermal cortex in *Leucetta* and *Pericharax*, accompanied by great reduction in the size of the flagellate chambers and complication of the inhalant and exhalant canal systems. In this way has arisen that remarkable convergence between *Leucetta* and *Pericharax* on the one hand, and the leuconoid Grantiidæ on the other, which has for so long prevented the appreciation of the fundamental distinction which really exists between these forms. The remaining genus in the family, *Leucomalthe*, is a highly specialised and aberrant type, which is only included here provisionally, until we know more of its minute anatomy and histology.

In the Leucaltidæ the distinctive peculiarity has been the enormous development of the dermal cortex with its special skeleton, and the accompanying reduction of the skeleton of the chamber layer to a more or less vestigial condition, or even its complete disappearance. In this family, again, as regards canal system, we meet with the customary transition from the long chambers and radial arrangement of the more primitive forms (*Leucaltis*) to the spherical chambers and scattered arrangement of the highest (*Leucettusa*).

To this line of descent must also be relegated two out of the three surviving families of "Pharetrones," namely, the Minchinellidæ and the Murrayonidæ. We found this conclusion upon the basal position of the nucleus in the collared cells in *Minchinella* and *Murrayona*; but it must be borne in mind that as regards their general organisation also the members of these two families differ very widely from *Lelapia* and *Kebira*, the only representatives of the Lelapiidæ, the third surviving family of "Pharetrones."

We are therefore compelled to regard the so-called family Pharetronidæ as of diphyletic origin, and the resemblance, such

as it is, between the *Lelapiidæ* on the one hand, and the *Minchinellidæ* and *Murrayonidæ* on the other, as due to convergence.

As to how many of the vast group of extinct "Pharetronid" sponges should be associated with the *Minchinellidæ* and *Murrayonidæ*, and how many with the *Lelapiidæ*, is a question which we cannot attempt to decide, but we think there is evidence to shew that the great majority belong to the basinucleate group, though this opinion, of course, rests only on skeletal characters. It seems highly probable that in past times the *Dendya* line of descent led to the evolution of the dominant Pharetronid group, while at the present day this group has dwindled away and has been replaced chiefly by the now dominant *Grantiidæ* on the apicinucleate line of descent.

The great antiquity of the Pharetronid group, considering its high degree of organisation, is highly remarkable. It dates back far into the Palæozoic Epoch, perhaps even to Silurian times [Ulrich, 1889], and almost certainly to Devonian [Zittel, 1878], so that it seems that the *Calcarea* had already reached one of their highest states of evolution at the commencement of the Palæozoic Epoch. Throughout the Secondary Period the Pharetrones were dominant, and very numerous genera and species have been described, whereas at the present day they are almost extinct, though possibly a few more forms yet remain to be discovered.

Of course it is quite possible that the predominance of the Pharetrones over other types of *Calcarea* in past times is apparent rather than real, owing to the fact that they alone, on account of their coherent skeleton, had much chance of being preserved in a fossil condition. Thus there may have been a kind of "geological selection" of these forms in a fossil condition, but it is indeed noteworthy that the apparently much more primitive groups should predominate over these ancient and highly specialised forms to such an extent as they do at the present day.

It is possible that a fresh outburst of evolutionary vigour on the part of the more primitive persistent groups may have occurred in comparatively recent times.

Turning now to the *Sycettid* line of descent, we must remind the reader, in the first instance, that this appears to have given rise to the vast majority of the recent *Calcarea*.

The most primitive genus on this line appears undoubtedly to be *Sycetta*, with its radially arranged chambers standing entirely separate from one another, with no trace of dermal cortex, and without tufts of oxea at the distal ends of the radial chambers. This genus already possesses a well-developed articulate tubar skeleton, the first joint of which is composed of subgastral sagittal triradiates, which appear never to have been developed along the *Dendya* line of descent, but which are remarkably constant throughout the whole of the *Sycettid* line, although

absent by suppression in a few cases where the skeleton has undergone extreme modification. We are unable to indicate any intermediate forms between the genus *Sycetta* and the Homocelidae. It presumably arose from some homocel ancestor which formed colonies by radial budding, not unlike those of *Dendya*, but the apical position of the nucleus of the collared cells and the much more advanced type of skeleton shew that the relationship to *Dendya* itself cannot be a close one, while the interval to be bridged over between the most primitive *Sycetta* and any *Leucosolenia* is a very wide one. Moreover, *Sycetta* itself seems to be in the nature of a *cul-de-sac*, for the entire absence of the characteristic oxoete spicules of *Sycon* makes it doubtful whether we can derive the latter genus directly from the former, though both have probably sprung from some common ancestor. If, however, *Sycon* derives its oxea from an ancestral *Leucosolenia*, it is difficult to account for the absence of these spicules in *Sycetta*, but the distribution of oxea in the Calcarea is an extremely difficult problem about which we have perhaps said enough in an earlier part of this paper.

The fact that certain species of *Sycon*, for which von Lendenfeld [1885 A] proposed his genus *Homoderma*, retain the collared cells as a lining to at any rate a portion of the central gastral cavity throughout life, certainly shews that one can draw no hard and fast line of distinction between the Homocelidae and the old group Heterocœla in this respect, but the forms in question have such a highly specialised syconoid skeletal system that they hardly help us to bridge over the interval between the Homocelidae and the Sycettidae.

The family Sycettidae is a very small one, the typical genus being *Sycon* with a large number of species, while the only other known genera are *Sycetta* and *Sycandra*, each with a very small number of species and each representing an offshoot which probably leads no further. From the Sycettidae two lines of descent appear to lead to the Heteropiidae and Grantiidae respectively.

In both these families the important step in further evolution, as in the Leucascidae and the Leucatiidae, has been the development of a dermal cortex, but this cortex appears to have arisen somewhat differently in the two cases. In the Heteropiidae it is clearly associated with the out-turning of certain of the oral rays of the distal tubar triradiates so as to arch over the entrances to the inhalant canals. We may assume that with these rays the dermal tissues of the sponge have spread over the intercanals and have given rise ultimately to the special cortical spicules developed *in situ*. The rotation of the distal tubar triradiates in the manner indicated, and the preponderating development of the now centripetally directed oral rays, have finally converted these spicules into the "pseudosagittal" triradiates which

constitute the outstanding feature of the Heteropiidae. They are, so to speak, a new discovery, which the sponge utilizes to the utmost, until finally their strong centripetally directed oral rays, in association with the opposed basal rays of subgastral sagittal triradiates, give rise to an "inarticulate" tubar skeleton, which replaces the articulate tubar skeleton of the ancestral *Sycon*.

The evolution of the canal system within the family appears to have followed the usual lines up to a certain point. The known species of *Fosmaeropsis* exhibit the type of canal system described by von Lendenfeld as "syllleibid," intermediate between syconoid and leuconoid, but a Heteropiid with a typical leuconoid canal system has not yet been found.

In the Grantiidae, on the other hand, the development of a dermal cortex appears to have been inaugurated by the appearance of a thin pore-bearing dermal membrane over the ends of the inhalant canals in some syconoid ancestor, such as is known to occur in some species of the genus *Sycon* at the present day (e.g. *S. boomerang*).

The Grantiidae must be regarded as the dominant family of Calcareia at the present day, comprising, as they do, no less than 23 genera, and exhibiting a very wide range of structure both as regards skeleton and canal system. It might be possible to divide these genera into syconoid and leuconoid subfamilies, but we should have no guarantee of the monophyletic origin of the latter from the former. Nevertheless, the scarcity of syllleibid forms, which might be regarded as connecting links between the two types, is somewhat remarkable, and suggestive of a natural cleavage. The known species of the genus *Megapogon*, however, are syllleibid, and although most of the Leucandras have small chambers, *L. australiensis* Carter and *L. infesta* sp. n. (= *Leucilla intermedia* Row [1909]) have very large ones, and might also be considered as transitional forms. Also we must remember that in a considerable number of cases we have no accurate information as to the canal system.

The arrangement of the genera within the family is a very difficult problem. They appear to group themselves around two central types, *Grantia* and *Leucandra*, but as we have just mentioned, our knowledge of the exact type of canal system in many forms is very imperfect, while in others the only evidence of their close relationship to *Leucandra* is the canal system itself. The appearance of this part of our phylogenetic tree will probably be greatly modified by subsequent investigations. Such aberrant genera as *Leucopsila*, *Baeria*, *Kuarrhaphis*, *Leucyssa* and *Trichogypsia* can only be included in the Grantiidae provisionally.

The difficulty of arranging the genera probably arises from the fact that great gaps exist in the family owing to extinction of intermediate forms. It might be argued that this family

cannot be very ancient, because hardly any of their fossil remains have been discovered, but this may possibly be accounted for by the fact that they do not possess a coherent skeleton, and accordingly become disintegrated soon after death.

It is, however, quite possible that some of the very imperfectly known extinct Pharetrones may really be offshoots from this family, as we believe to be the case with the recent *Lelapiidæ*. The customary association of the latter with the Pharetrones is based upon the presence of a fibrous skeleton composed of modified radiates, especially the tuning-fork spicule, and a fibrous skeleton of this type is perhaps present in some of the extinct genera. We have, however, purposely avoided discussing the latter in this paper, as we do not know enough about them to warrant us in drawing any but the most general conclusions. As we have already pointed out, the apical position of the nucleus of the collared cells in *Lelapia*, and the presence in it also of subgastral sagittal triradiates, render the Grantiid origin of the *Lelapiidæ* reasonably certain.

In addition to the *Lelapiidæ*, one other family, the *Amphoriscidæ*, seems to have originated from the Grantiid stock. This family derives its distinctive character from the development of strong, centripetally directed apical rays on the tangential radiates of the dermal cortex. Such apical rays have undoubtedly appeared several times independently in the evolution of the *Calcarea*. We find them, for example, in some species of *Leucetta*, in *Leucaltis*, in some species of *Leucettusa*, in one species of *Grantia* (*G. intermedia*), in some species of *Leucandra*, and in *Grantilla*, as well as in this group. It may well seem doubtful whether, in view of these facts, the character in question ought to be regarded as of family significance in the *Amphoriscidæ*; but inasmuch as the latter appear to us to comprise a natural assemblage of three closely related genera in which this character is no longer casual but has assumed great importance in the structure of the skeleton, we have decided to retain the group, at any rate for the present. We have, however, considerably reduced the size of the family by the removal of *Leucaltis* (*Heteropegma*), together with some of the species formerly placed in *Leucilla*, but now divided between *Leucetta*, *Leucettusa* and *Leucandra*, to which they seem to be more closely affiliated by other characters, leaving in the genus *Leucilla* a group of species which are, we believe, all directly descended from *Amphoriscus*.

The most primitive *Amphoriscidæ*, belonging to the genus *Amphoriscus*, have a syconoid canal system and a somewhat feebly developed dermal cortex, and we accordingly consider the family to be an offshoot from low down on the Grantiid stem. Finally, we may point out that in this family again the canal system has undergone its usual transformation from the syconoid to the leuconoid type, with intermediate sylleibid forms.

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## EXHIBITIONS AND NOTICES.

May 20, 1913.

Prof. E. A. MINCHIN, M.A., F.R.S., Vice-President,  
in the Chair.

The SECRETARY read the following report on the Additions that had been made to the Society's Menagerie during the month of April, 1913 :—

The registered additions to the Society's Menagerie during the month of April were 205 in number. Of these, 95 were acquired by presentation, 79 by purchase, 9 were received on deposit, 1 in exchange, and 21 were born in the Gardens.

The number of departures during the same period, by death and removals, was 156.

Amongst the additions special attention may be directed to :—

1 White-handed Gibbon (*Hylobates lar*), from Penang, deposited on April 10th.

1 Maholi Galago (*Galago maholi*), from S. Africa, presented by Lady Yule, F.Z.S., on April 8th.

1 Bangs's Agouti (*Dasyprocta colombiana*), 1 Bonda's Squirrel (*Sciurus saltuensis bondae*), from Colombia, both new to the Collection, presented by W. K. Pomeroy, Esq., F.Z.S., on April 21st.

A Collection of Birds, from North-West India, presented by Major G. A. Perreau, F.Z.S., on April 1st, of which the following are new to the Collection :—

1 Dark Grey Bush-Chat (*Oreicola ferræ*), 1 Plumbeous Redstart (*Rhyacornis fuliginosa*), 1 Red-flanked Bush-Robin (*Ianthia rufilata*), 2 White-tailed Blue Robins (*Notodola leucura*), 1 Great Niltava (*Niltava grandis*), 2 Short-billed Minivets (*Pericrocotus brevirostris*), 1 Larger Red-headed Crow-Tit (*Scecorhynchus ruficeps*), 1 Cinnamon-bellied Nuthatch (*Sitta cinnamomeiventris*), 1 Grey-sided Laughing Thrush (*Dryonastes caeruleatus*), 4 Rufous-necked Laughing Thrushes (*Dryonastes ruficollis*).

1 Bushmaster (*Lachesis mutus*), from Trinidad, presented by the Baron E. G. E. Leijonhufvud, F.Z.S., on April 28th.

1 large Anaconda (*Eunectes murinus*), from Trinidad, purchased on April 28th.

The Rev. T. R. R. STEBBING, M.A., F.R.S., F.Z.S., drew attention to Prof. F. E. Schulze's important work on zoological nomenclature, the 'Nomenclator Animalium,' giving a brief description of its objects and scope, and urging its claims for assistance from British naturalists.

The LIBRARIAN submitted the following list of dates of publication of the early parts of the Society's "Transactions," which had been drawn up from the records kept by Messrs. Taylor and Francis, the Society's printers.

The date of issue of Parts subsequent to Vol. VII. Part I appears at the foot of each sheet.

#### VOLUME I.

Part.	Pages.	Plates.	Published.
1.	1-90.	I.-XII.	Aug. 14, 1833.
2.	91-194.	XIII.-XXVI.	Apr. 23-25, 1834.
3.	195-300.	XXVII.-XXXVII.	Mar. 20, 1835.
4.	301-407.	XXXVIII.-LIX.	Dec. 3, 1835.

#### VOLUME II.

1.	1-86.	I.-XVII.	Oct. 2, 1836.
2.	87-164.	XVIII.-XXIX.	May 4, 1838.
3.	165-248.	XXX.-XLV.	Dec. 5, 1838.
4.	249-342.	XLVI.-LVIII.	Apr. 6, 1840.
5.	343-420.	LIX.-LXXI.	May 15, 1841.



## VOLUME III.

<i>Part.</i>	<i>Pages.</i>	<i>Plates.</i>	<i>Published.</i>
1.	1-132.	I.-VI.	June 16, 1842.
2.	133-234.	VIII.-XVII.	Jan. 23, 1844.
3.	235-276.	XVIII.-XXX.	June 5, 1844.
4.	277-344.	XXXI.-LI.	Dec. 28, 1846.
5.	345-380.	LII.-LVII.	Apr. 22, 1848.
6.	381-431.	LVIII.-LXIII.	Apr. 30, 1849.

## VOLUME IV.

1.	1-30.	I.-VIII.	Jan. 1, 1851.
2.	31-74.	IX.-XXV.	Mar. 2, 1852.
3.	75-88.	XXVI.-XXX.	Apr. 29, 1853.
4.	89-148.	XXXI.-XLII.	May 10, 1856.
5.	149-182.	XLIII.-LIII.	Sept. 28, 1858.
6.	183-268.	LIV.-LXIII.	Aug. 31, 1859.
7.	269-352.	LXIV.-LXVII.	Aug. 23, 1861.
8.	353-382.	LXVIIa.-LXXVII.	Sept. 15, 1862.

## VOLUME V.

1.	1-32.	I.-XIII.	June 11, 1862.
2.	33-102.	XIV.-XXVI.	May 27, 1863.
3.	103-242.	XXVII.-XLII.	Apr. 28, 1864.
4.	243-336.	XLIII.-LII.	Apr. 5, 1865.
5.	337-421.	LIII.-LXVII.	June 6, 1866.

## VOLUME VI.

1.	1-48.	I.-XIV.	Aug. 15, 1866.
2.	49-86.	XV.-XXIV.	Jan. 11, 1867.
3.	87-124.	XXV.-XXX.	Mar. 28, 1867.
4.	125-226.	XXXI.-XLIII.	Nov. 5, 1867.
5.	227-308.	XLIV.-LIV.	Feb. 19, 1868.
6.	309-376.	LV.-LXII.	June 4, 1868.
7.	377-494.	LXIII.-LXXXVII.	Sept. 15, 1868.
8.	495-537.	LXXXVIII.-XCII.	June 1, 1869.

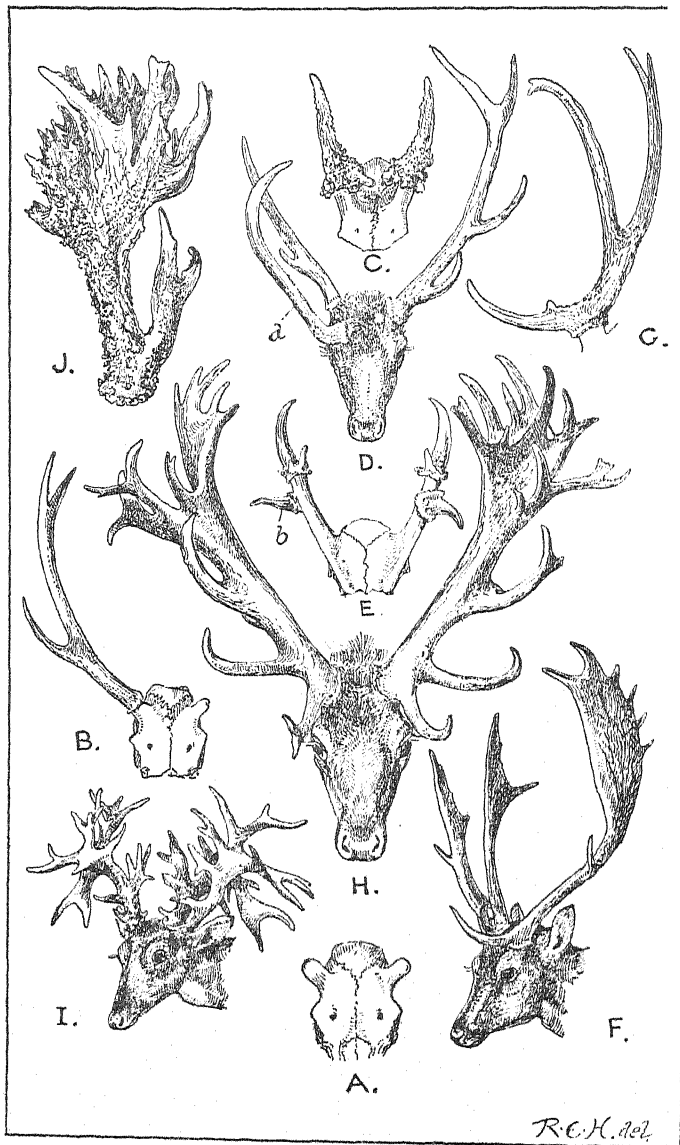
## VOLUME VII.

1.	1-144.	I.-VI.	Oct. 20, 1869.
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Mr. R. E. HOLDING exhibited a number of antlers, skulls, and photographs illustrating variations in the growth of the Antlers of Deer, and stated that antlers were liable to considerable variation in form, due either to exuberance or proliferation of growth, or to congenital defect in the embryonic stage as in the case of the "Hummel" or Hornless Stag (text-fig. 134 A), which occasionally made its appearance in Scottish and continental Deer forests.

Text-fig. 134.



- A. Upper portion of the skull of a "Hummel" or Hornless Stag, aged 5 years.  
 B. Upper portion of the skull of Red Deer (*Cervus elaphus*), with deficient right and arrest of left antler.  
 C. First antlers of young Wapiti Stag (*Cervus canadensis*), showing unusual growth of nodules and "burr."

Sometimes the arrest was on one side only, producing the Single-horned Stag as shown (B). Occasionally a small supernumerary horn might grow below the Burr or Coronel (*b*), as shown in the figures of Muntjac (E) and Red Deer (D), probably due, as in the Four-horned Sheep, to accessory centres in the pedicle or horn support. Other variations, and by far the most common, were due to dichotomy, bifurcation, or segmentation of the beam or of the tines. That favourable environment and ample food promoted variation in the direction of exuberance or proliferation of points was well demonstrated by the photographs from Warnham Court and by illustrations in Mr. Winans' book "Deer-breeding for Fine Heads," published by Messrs. Rowland Ward. On the other hand, head-keepers and others in charge of Scottish Deer forests, had observed that scarcity of food, hard weather, and exposure have a marked effect on the antlers of Deer, causing deficiency in growth, bad form, and degeneration.

It was not often, at least in Scotland, that a stag with a good head escaped the attention of the owner or lessee of the Forest, and therefore defects and variations due to extreme age were seldom seen in the Red Stag, but in the Park Fallow Deer a marked change took place in the form of the palmation of the antler due to advancing age.

Malformations and variations due to accident, castration, or wounds, were not referred to, as being pathological.

Of the specimens exhibited in illustration of his remarks, Mr. Holding drew special attention to the antler of a Sambar stag (J), showing excessive proliferation of points, and an exceptionally fine pair of antlers lent by Mr. C. J. Lucas, of Warnham Court.

Explanation (*continued*) of Text-fig. 134 (see opposite).

- D. Head of Stag shot in Jura Forest, showing supernumerary right antler (*a*) growing from a separate pedicle on the frontal bone.
- E. Muntjac (*Cervulus muntjac*), showing supernumerary horns (*b*) springing from the long pedicle.
- F. Head of Fallow-buck (*Cervus dama*), showing dichotomy or bifurcation of beam of right antler at the "burr."
- G. Antler of Axis Deer (*Cervus axis*), the bifurcation occurring above the burr.
- H. Head of Red Stag from Warnham Park, having 42 points. From photograph by J. G. Millais, Esq., F.Z.S.
- I. Head of White-tailed Deer (*Cariacus leucurus*), showing excessive proliferation. Shown by Capt. Frewen at a recent Exhibition of American trophies.
- J. Antler of Sambar Deer (*Cervus unicolor*), showing profuse growth of "points" obliterating the normal character of the antler.

June 3, 1913.

Prof. E. W. MACBRIDE, M.A., D.Sc., F.R.S., Vice-President,  
in the Chair.

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited the egg and young of the Mikado Pheasant (*Calophasis mikado*), a rare species, described first in 1906, from the mountains of Formosa. Some living specimens had been imported in 1912 by Mr. Walter Goodfellow, and the owners of these birds had entrusted the eggs to the Zoological Society, where they were being hatched.

The egg was cream-coloured and very large compared with those of allied species of pheasants, measuring  $57 \times 41$  mm.

The incubation period proved to be twenty-eight days, instead of twenty-four as in the majority of pheasants, and the young when newly hatched were very large, and had the quill-feathers better developed than was the case in allied species.

#### PAPERS.

45. The Transvaal Race of the Cape, or Khama, Hartebeest\*.

By R. LYDEKKEER, F.R.S., F.Z.S. †

[Received April 1, 1913: Read April 8, 1913.]

(Text-figure 135.)

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Description of <i>Bubalis caama selbornei</i> .....	819

In their excellent volume, 'The Sportsman in South Africa,' Messrs. Nicolls and Eglington describe (p. 45) the Cape, or Rooi, Hartebeest (*Bubalis caama*), probably from fresh specimens, as follows:—

"General colour reddish brown, with violet tinge throughout; dark plum-coloured saddle-patch, commencing at point of shoulder, extends over entire surface of back and ends in root of tail; a similar patch extends over each shoulder, downwards as far as knees, and front of shin-bones of fore-legs; pale yellowish patch on cheeks of rump; front of face, which is very long, almost black, as is a stripe down back of neck."

In their figure of the head (pl. iv. fig. 13) the broad face-blaze is shown as extending uninterruptedly from the base of the horns

\* [The complete account of this new subspecies appears here, but since the name and a preliminary diagnosis were published in the 'Abstract,' No. 119, 1913, it is distinguished by being underlined.—EDITOR.]

† By permission of the Trustees of the British Museum.

to the muzzle; but, in many cases at any rate, this is divided by a narrow tawny line at the level of the eyes. They omit to mention a plum-coloured patch on the side of the thighs below the light area, extending to the hocks.

In the 'Book of Antelopes,' by Messrs. Selater and Thomas, an obviously over-coloured plate (no. iv.) of the entire animal is given, in which the dark face-blaze, divided by an interocular light bar, and the dark markings on the fore and hind limbs are clearly shown, although there is no sign of a plum-coloured saddle-patch. The authors describe the general colour as brownish fulvous, darker than in any other member of the genus.

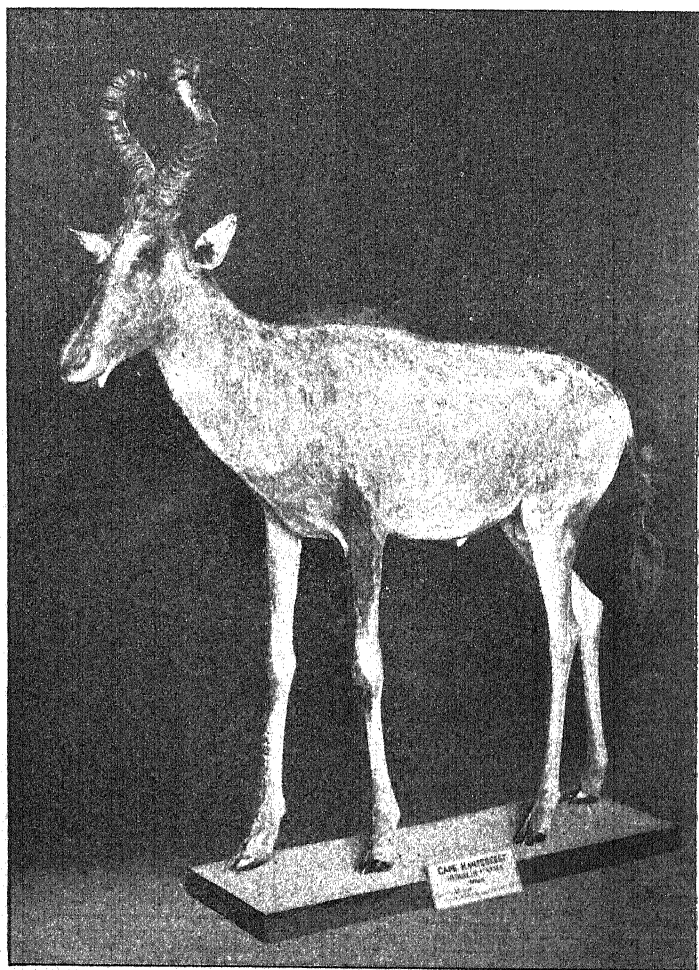
The only specimen of an adult male Cape Hartebeest from Cape Colony in the British Museum is one obtained by Sir Andrew Smith, which has recently been dismounted and converted into a flat skin. Although much faded by long exposure, it serves to show that the type of colouring was originally much the same as in the plate in the 'Book of Antelopes.'

A few years ago Lord Selborne was good enough to offer to endeavour to procure for the Museum specimens of such South African Antelopes as might be required for public exhibition; and as a result of his lordship's request the skin, skull, and horns of an adult male of the Transvaal representative of the Cape Hartebeest were received at the Museum in 1912, as a gift from the De Beers Mining Company. The specimen was in due course set up by Rowland Ward, Ltd., and placed on exhibition in the galleries in lieu of the old and faded example from Cape Colony referred to above. At the time I was busy with other matters, and consequently did not pay any attention to the details of the new acquisition. Recently, however, I have had occasion to review all the Hartebeests in the collection; and this survey has left no doubt that the Transvaal Hartebeest, which was shot in the neighbourhood of Kimberley, represents a very distinct undescribed race of *Bubalis caama*.

From the typical Khama this race differs by its much paler general colouring, which is yellowish fawn or tawny, not unlike that of *B. cokei*, by the minor development and intensity of the dark markings, and by the apparently less sharp definition of the white on the sides and back of the lower part of the rump. The general tawny tint tends to chestnut on the loins, as in *B. cokei*, but elsewhere the back is of much the same colour as the flanks. The nuchal stripe is indistinct; and the face-blaze, instead of forming, with the exception of the narrow light band between the eyes, a continuous wholly black streak from the horns to the muzzle, is much broken up, and everywhere mingled with fawn-coloured hairs. It practically stops short of the horns, and is interrupted in the neighbourhood of the eyes by a fawn area, mingled with a few blackish hairs, for a length of about four inches, while the nasal portion does not nearly reach the muzzle. Then, again, the dark patch on the shoulder and fore-leg is much less intense than in the typical race, and is everywhere mingled with fawn

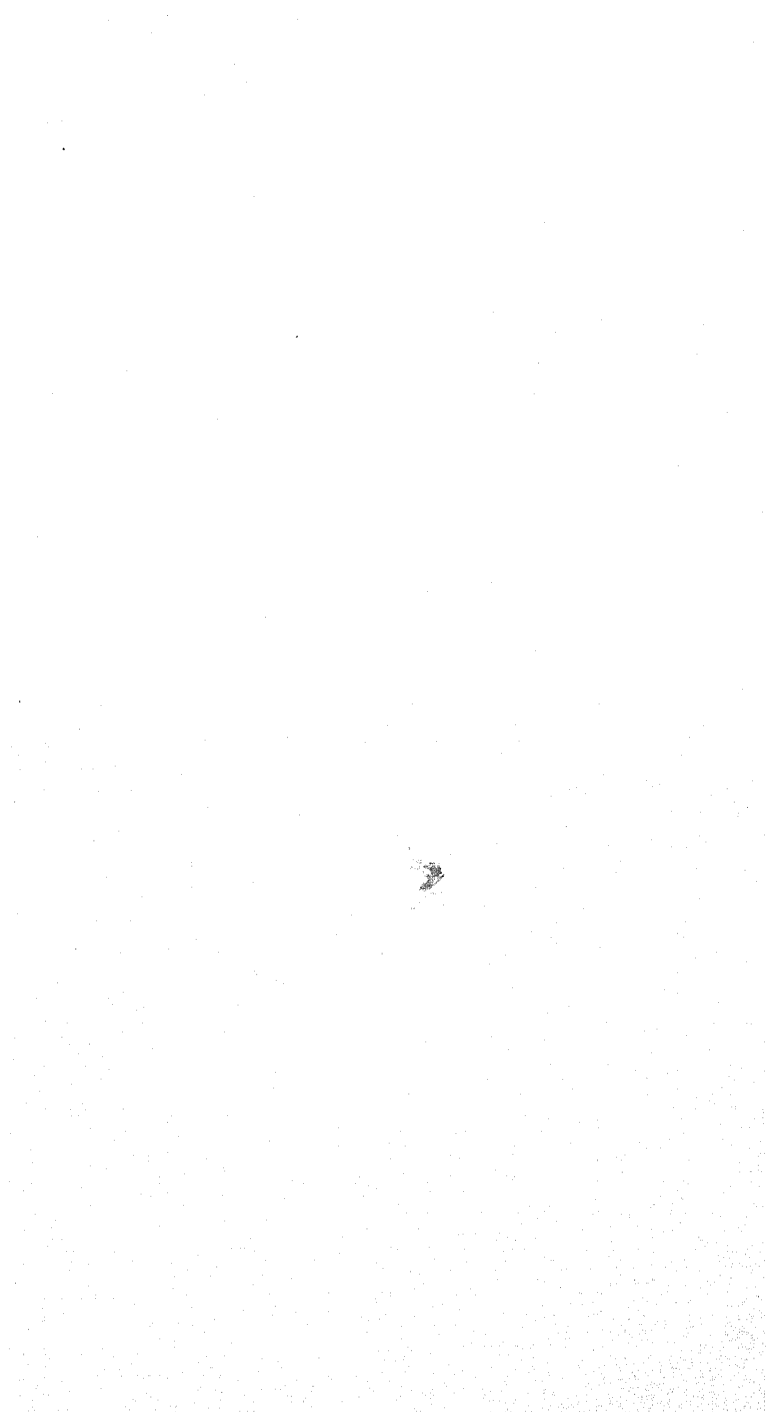
hairs, while it stops short of the knees, on which it forms a dark patch, and on the shanks is represented solely by a very small patch at about the middle of their length. The same lack of intensity characterises the dark area on the thighs, which appears to be smaller than in the typical southern race.

Text-fig. 135.



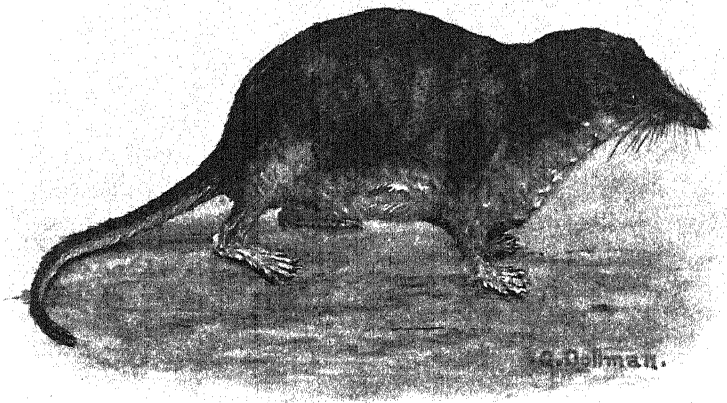
Transvaal Khama Hartbeest (*Bubalis caama selbornei*).

The Transvaal race, which is typified by the aforesaid mounted buck, and may be named *Bubalis caama selbornei* [Abstract





1



2

*G. Dollman, del.*

*Henry Stone & Son, Ltd., Banbury*

1. SOREX GRANTI.

2. S. ARANEUS CASTANEUS.



P. Z. S. 1913, p. 19 (April 15)], cannot, indeed, be described as a "Rooi" (red) Hartebeest; and is evidently a form which is either losing or acquiring—I cannot say which—the rufous body-colour and deep purplish-black markings of the typical southern Khama. The two races may be defined as follows:—

- a. General colour rich rufous-brown; face-blaze black and extending, with the exception of a narrow fawn band between the eyes, from horns to muzzle; limb-markings plum-colour, and forming a continuous stripe on front of fore-legs.

*B. caama typica.*

- b. General colour yellowish fawn; face-blaze mingled with tawny, stopping short of horns and muzzle, and interrupted by a long interval in region of eyes; limb-markings mingled with tawny, interrupted above knees, on which they form a cap, and represented by a small patch on front of shanks.

*B. caama selbornei.*

46. On a Collection of Mammals from the Inner Hebrides.  
By G. E. H. BARRETT-HAMILTON, F.Z.S., and MARTIN  
A. C. HINTON.

[Received and Read April 8, 1913.]

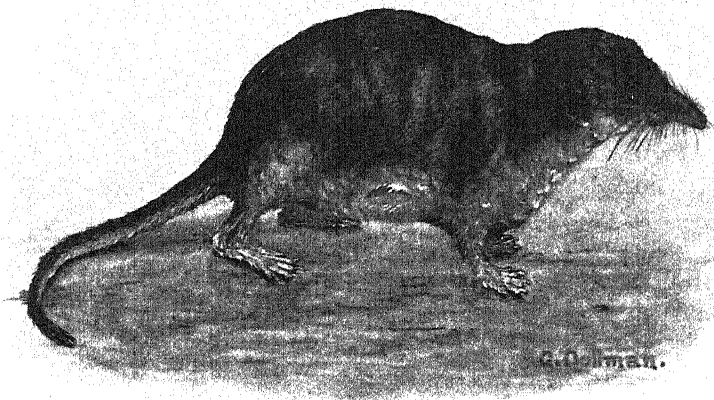
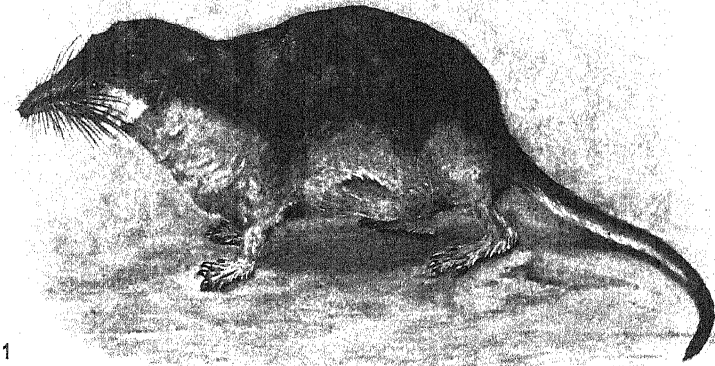
(Plate LXXXIV.\* and Text-figures 136–138.)

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The peculiar mammals of high interest yielded by investigation of the peripheral regions of the British Islands, led Barrett-Hamilton to believe that further valuable results might be obtained by a closer study of the mammals of the Scottish Islands. The despatch and management of collectors was, however, an undertaking beyond his means and available time, and the matter hung fire until taken up by Mr. W. R. Ogilvie-Grant, whose enthusiasm as manager and collector of funds has made it possible to amass the material on which this paper is based.

Early in 1912 Mr. R. W. Sheppard was sent to the Inner Hebrides, and commencing to collect at Bute, this young naturalist gradually worked his way northwards through the group as far as Coll, which he reached in July. As small mammals are difficult

\* For explanation of the Plate see p. 839.



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*B. caama selbornei.*

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[Received and Read April 8, 1913.]

(Plate LXXXIV.\* and Text-figures 136-138.)

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\* For explanation of the Plate see p. 839.

to catch during the summer months, further investigation of the islands was then postponed.

Among those who have assisted the work of exploration, either financially or with local assistance, we may specially mention the Duke of Argyll, the Marquis of Bute, Mr. A. R. Macgregor, Mrs. Hugh Morrison of Islay, Mr. Colin Campbell of Jura, and Mr. Harold Russell.

The present collection has come well up to expectations, since it has resulted in the discovery of three quite distinct forms belonging to the genera *Sorex*, *Evotomys*, and *Microtus*\*.

In working out the fauna of small islands, two distinct phenomena must be disentangled. A peculiar mammal found on a small island may represent a new development under insular conditions, it may represent the survival of an ancient type elsewhere extinct, and, as is often the case, it may combine both features. We believe that *Sorex grantii* is an entirely new development, and that *Evotomys alstoni* and *Microtus agrestis macgillivrayi* are instances of "relics" surviving with little alteration from the pleistocene epoch. The meaning of these three forms has been partly discussed under the description of each of them; but it would be premature to enter upon an extended discussion of the cause of variation or survival in islands. The influence of a comparatively recent glacial period, and the extermination brought about by man, now proved to be an ancient inhabitant of Britain, are difficult to follow; and at all periods the British Islands have been the scene of constantly shifting environments and altering or variable climates, due principally to the proximity of a great ocean and the frequent oscillations of sea-level. Many of our common genera of mammals have inhabited the British Islands since the deposition of the late pliocene Forest-Bed, but no one has as yet ventured to guess how often they may have been exterminated, to return again in fresh vigour on the resumption of favourable conditions. The history of the British fauna resolves itself into that of the various invasions or "migrations" of mammals, which have been no less real, albeit more ancient and more difficult to trace, than those of Kelt, Roman, Saxon, Skandinavian, and Norman. The severity of the struggle for existence has in our area undergone profound variation, according as the sea cut off or united our area with Europe, according as severe climatic conditions were combined with insularity or connection with the Continent. But, however frequently the fauna may have been exterminated, renewed junctions with the mainland have from time to time refreshed it with new stock, and the geological records of what seem from a distance almost kaleidoscopic changes are only now in process of disentanglement.

\* [The complete account of these new forms appear here, but since the names and preliminary diagnoses were published in the 'Abstract,' No. 119, 1913, they are distinguished by being underlined.—EDITOR.]

## SOREX ARANEUS CASTANEUS Jenyns. (Pl. LXXXIV. fig. 2.)

## Three, GREAT CUMBRAE.

## Dimensions\* :—

			Head & body.	Tail.	Hind foot.
No. 34, male,	28 March 1912	.....	70	33	12
32, female,	27     "     "	.....	70	33	13
39,     "     "	30     "     "	.....	67	32	11
Average of 3 specimens of both sexes :—			69	32·6	12

## Eight, BUTE.

No. 13, male,	19 March 1912	.....	70	37	12
65,     "     "	18 April     "     "	.....	77	33	12
68,     "     "	19     "     "	.....	70	32	12
71,     "     "	20     "     "	.....	70	36	12
14, female,	19 March     "     "	.....	65	32	12
15,     "     "	"     "     "	.....	65	32	12
16,     "     "	"     "     "	.....	65	33	12
66,     "     "	"     "     "	.....	73	32	12
Average of 8 specimens of both sexes :—			69·37	33·37	12

## Three, ARRAN.

No. 58, male,	10 April 1912	.....	72	36	12
57, female,	"     "     "	.....	70	36	12
60,     "     "	11     "     "	.....	75	36	12
Average of 3 specimens of both sexes :—			72·33	36	12

## Four, MULL.

No. 143, male,	29 June 1912	.....	78	35	12
144,     "     "	3 July     "     "	.....	75	33	12
138, female,	21 June     "     "	.....	68	40	12
142,     "     "	28     "     "	.....	68	38	12
Average of 4 specimens of both sexes :—			72·25	36·5	12

## Six, JURA.

No. 108, male,	15 May 1912	.....	70	36	12
110,     "     "	"     "     "	.....	73	35	12
112,     "     "	16     "     "	.....	76	36	12
111, female,	15     "     "	.....	73	36	12
120,     "     "	18     "     "	.....	70	33	12
121,     "     "	"     "     "	.....	73	36	12
Average of 6 specimens of both sexes :—			72·5	35·3	12

For cranial measurements see Table at p. 828.

The specimens from Great Cumbrae, Bute, Arran, and Mull do

\* Collectors' measurements : throughout hind feet without claws, tail without terminal hairs. All dimensions are given in millimetres.

not differ appreciably from examples of *castaneus* from the neighbouring mainland. Skulls of *castaneus* from South-eastern England seem to attain slightly larger dimensions than those from northern Britain, and this may indicate the existence of two forms. The Jura Shrew is interesting in having a pelage intermediate in character between that of *castaneus* and *granti* described below; in the four skulls seen the dental characters are those of normal *araneus*, and therefore this form must be left with the latter species.

SOREX GRANTII. (Pl. LXXXIV. fig. 1, & text-fig. 136.)

Abstract P. Z. S. 1913, p. 18 (April 15).

Twenty-two, ISLAY.

Dimensions:—

					Head & body.	Tail.	Hind foot.
No. 73, male,	24 April 1912	.....			75	36	13
74, " "	" " "	.....			77	36	13
77, " "	26 " "	.....			79	37	13
80, " "	30 " "	.....			80	36	13
82, " "	" " "	.....			80	36	13
83, " "	" " "	.....			80	37	13
84, " "	" " "	.....			78	38	13
92, " "	2 May "	.....			78	35	12
95, " "	" " "	.....			75	35	12
98, " "	7 " "	.....			75	35	12
100, " "	8 " "	.....			75	35	12
101, " "	" " "	.....			76	36	12
105, " "	10 " "	.....			75	36	13
72, female,	23 April "	.....			83	37	13
76, " "	26 " "	.....			75	37	13
81, " "	30 " "	.....			78	36	13
96, " "	3 May "	.....			77	35	12
106, " "	10 " "	.....			75	35	12
157, female, juv.,	3 Aug. 1912	...			75	38	12
158, " "	" " "	...			80	34	12.5
161, " "	" 5 " "	...			73	36	12
165, " "	" 8 " "	...			70	38	12
Average of 18 adults of both sexes:—					77.3	36	12.6

For cranial measurements see Table at p. 828.

This is a very remarkable new Shrew, distinguishable at a glance from the common British *S. araneus castaneus* by its dusky upper side in strong contrast to the light flanks. The dentition is peculiar in the fact that more than half of the individuals have lost the posterior upper unicuspid, sometimes on one side only, but more frequently on both sides, the absence of this tooth in these cases being compensated for by enlargement of the four remaining unicuspid

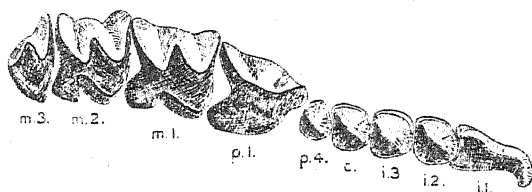
DESCRIPTION.—The size and proportions are about as in *S. araneus castaneus*, but average slightly larger than in north British specimens of the latter.

*Colour*.—Adults have the upper side deep blackish brown, perhaps darker than “clove-brown”<sup>\*</sup>; slightly grizzled on the upper side of the head and neck with brown; the under side is silvery or smoky grey rather than yellowish or brownish as in *castaneus*, and this colour runs far up the flanks and shows up in contrast to the dark upper side. Between the colours of upper and under sides a narrow, inconspicuous, grey-brown flank-band intervenes; rarely it is “wood-brown,” in which case it contrasts more sharply with the back. Nos. 72 & 76 (23 & 26 April) are moulting into a scarcely less dusky summer coat, but some specimens taken in May and Nos. 157, 161. & 165 (3, 5, & 8 August) are in a lighter brown coat, between “seal-brown” and “clove-brown,” somewhat as in *S. a. castaneus*, with a flank-band near-“wood-brown.” These specimens are no doubt immature and the brown pelage is that of immaturity.

*Cranial and dental characters*.—The skull agrees in form and size with that of *S. a. castaneus*, but attains rather larger dimensions than skulls of the latter species from northern Britain and the Inner Hebrides (*vide* Table, p. 828). The teeth agree in form with those of *S. araneus*; but the posterior unicuspid (p. 3) tends to disappear as shown by the following statistics:—

p. 3 present on both sides in	7 individuals, <i>i. e.</i> 43·7 per cent.
“ “ on one side only in	4 “ “ 25 “
“ absent on both sides in	5 “ “ 31·3 “

Text-fig. 136.



Right upper tooth-row of *Sorex grantii*.  $\times 8\frac{1}{2}$ .

When p. 3 is absent the four remaining unicuspid teeth appear to be somewhat enlarged in compensation (text-fig. 136). There is no trace of pigment on the hypocones of the upper cheek-teeth nor on protocone of the last upper molar.

By colour and dentition *S. grantii* is clearly differentiated from all European members of the genus *Sorex*. Some of these, such as *araneus araneus* and *araneus tetragonurus*, have the back as dark, but none shows the conspicuously contrasted sides.

\* The names of colours in inverted commas are from Ridgway.

In our opinion *S. grantii* is to be regarded as an insular development of *S. a. castaneus* stock. It has maintained or acquired slightly larger dimensions than has the latter in the more northern parts of its range; it has developed a peculiar colour pattern, and is well on its way to reduce the number of its unicuspid teeth, perhaps because of a tendency to enlarge the anterior members of the series. The Jura Shrew is geographically and morphologically the connecting link between *S. a. castaneus* and *S. grantii*: it has the small size and dental characters of the northern *castaneus*; but its colour pattern is modified so as to approach that of *S. grantii*.

The species is named in honour of Mr. W. R. Ogilvie-Grant of the British Museum, to whose enthusiasm the formation of the collection described in this paper is so largely due.

#### SOREX MINUTUS Linnaeus.

##### Nine, BUTE.

						Dimensions:—		
						Head & body.	Tail.	Hind foot.
No. 18,	male,	adult,	20 March 1912	...		52	35	10
25,	"	"	25 " " "	...		55	35	10
70,	"	"	20 April " "	...		55	34	10
2,	female	"	12 March " "	...		45	32	10
17,	"	"	20 " " "	...		55	35	10
19,	"	"	" " " "	...		55	33	10
24,	"	"	" " " "	...		50	35	10
26,	"	"	" " " "	...		55	35	10
69,	"	"	20 April " "	...		55	35	10
Average of 9 specimens of both sexes:—						53	34.3	10

All in dark adult pelage, between "seal-brown" and "hair-brown."

##### Two, ARRAN.

No. 59,	male,	adult,	11 April 1912	...		58	35	10
51,	female,	"	6 " " "	...		59	35	11
Average of 2 specimens:—						58.5	35	10.5

In dark adult pelage as above.

##### Three, ISLAY.

No. 75,	male,	adult,	26 April 1912	...		60	40	10
85,	"	"	30 " " "	...		59	37	10
86,	female,	"	" " " "	...		57	37	10
Average of 3 specimens of both sexes:—						58.6	38	10

No. 85 is in dark adult pelage as above, Nos. 75 and 86 in juvenile or summer pelage.

##### One, COLL.

No. 56,	female,	adult,	23 July 1912	...		60	37	10
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## Five, TIREE.

## Dimensions:—

			Head & body.	Tail.	Hind foot.
No. 152, male, juv.,	16 July 1912 ...		50	34	10
153, " " "	" " " ...		50	34	10
154, " " "	" " " ...		50	34	10
155, " " "	17 " " ...		50	34	10
151, female, fully grown.	16 " " ...		60	36	10

The larger specimens from Coll and Tiree are in the light summer coat of young born in the same season; in this pelage the hairs are more plentifully grizzled or peppered with tawny than in adults. The very young specimens show an interesting early pelage, in which the upper side is lighter than in adults, the under side very clear and nearly white.

For cranial measurements see Table at p. 828.

Elsewhere in the Hebrides *S. minutus* is known to inhabit Skye, Eigg, Sanda, Great Cumbrae, Lewis, North and South Uist, Benbecula, and Barra. (Barrett-Hamilton, 'History of British Mammals,' ii. pt. 8, pp. 111-115.)

## EVOTOMYS GLAREOLUS BRITANNICUS Miller.

## Two, BUTE.

## Dimensions:—

			Head & body.	Tail.	Hind foot.	Ear.
No. 6, male, adolescent,	13 March 1912.		90	42	17	10
27, " adult,	21 " "		95	45	18	10

For cranial measurements see Table at p. 830.

With this material we are unable to distinguish the *Evotomys* of Bute from the form inhabiting the mainland. In No. 6 the cement-spaces of the cheek-teeth are just closed; in No. 27 the roots of the cheek-teeth are moderately developed. In each specimen the last upper molar has a third inner fold. The skull agrees in size and general form with that of *britannicus*, but the external measurements indicate a rather smaller animal with slightly larger hind feet than the latter.

## EVOTOMYS ALSTONI. (Text-fig. 137.)

Abstract P. Z. S. 1913, p. 18 (April 15).

## Five, MULL.

## Dimensions:—

			Head and body.	Tail.	Hind foot.	Ear.
No. 134, male, aged,	18 June 1912		108	44	18	11 Type
135, " " "	" " "		110	44	19·5	11·5
136, " " "	19 " "		103	44	18	11
128, female, "	13 " "		105	45	18·5	11·5
130, " " "	14 " "		100	42	18	10

Average of 5 specimens of both sexes: 105·2 43·8 18·4 11

For cranial measurements see Table at p. 830.

Cranial and Dental measurements of *Sorex*.

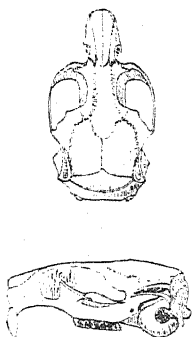
<i>S. araneus castaneus</i> .	Condylar-basal length.	Malar breadth.*	Interorbital breadth.	Width of brain-case.	Depth of brain-case.	Maxillary teeth.	Cheek-teeth (p. 1—m. 3).*	Tooth-row exclusive of inc. 1.*	Mandible.	Tooth-row exclusive of incisor.*	m. 1 to m. 3.*	Coronoid height.*	Condyle to anterior border of coronoid process.*	Height of ramus below m. 2.*
JURA.														
No. 111 .....	18.7	5.06	3.5	9.0	4.7	8.2	4.4	6.93	9.3	5.17	3.52	4.51	2.8	1.32
120 .....	18.2	5.17	3.5	9.2	5.0	7.7	4.29	6.6	9.3	5.17	3.52	4.29	2.75	1.43
MULL.														
No. 142 .....	18.7	4.84	3.5	9.0	...	8.1	4.51	6.93	9.4	5.28	3.63	4.4	2.86	1.32
143 .....	19.0	5.28	3.9	9.6	5.1	8.1	4.4	7.04	9.8	5.28	3.57	4.51	3.08	1.32
144 .....	17.7	4.84	3.3	8.9	4.9	7.6	4.18	6.49	9.0	4.95	3.52	4.4	2.86	1.32
BUTE.														
No. 13 .....	18.4	5.06	3.5	9.2	4.8	8.0	4.4	6.93	9.3	5.17	3.63	4.4	2.86	1.32
14 .....	18.4	4.95	3.5	9.0	4.8	7.9	4.4	6.82	9.3	5.06	3.52	4.4	2.97	1.32
15 .....	17.9	5.28	3.5	9.1	5.0	7.8	4.29	6.71	9.0	5.06	3.52	4.45	2.86	1.32
16 .....	18.5	5.12	3.5	9.2	4.9	7.9	4.29	6.82	9.2	5.17	3.63	4.4	2.86	1.43
68 .....	18.1	5.06	3.5	9.2	5.2	7.7	4.34	6.65	9.1	5.06	3.52	4.29	2.91	1.32
CUMBRAE.														
No. 32 .....	18.7	5.06	3.7	9.1	...	7.8	4.29	6.71	9.4	5.06	3.52	4.4	2.91	1.37
34 .....	18.9	5.28	3.7	...	...	7.9	4.29	6.93	9.7	5.17	3.52	4.51	2.97	1.32
39 .....	18.3	5.06	3.5	8.9	4.8	8.0	4.29	6.71	9.5	4.95	3.46	4.4	2.86	1.32
ARRAN.														
No. 57 .....	18.2	5.06	3.6	8.9	...	7.8	4.29	6.71	...	5.06	3.46	4.51	2.97	1.43
58 .....	18.6	5.22	3.6	9.4	5.0	8.0	4.4	6.93	9.3	5.11	3.57	4.62	2.97	1.37
<i>S. grantii</i> .														
ISLAY.														
No. 73 .....	19.1	5.28	3.7	9.3	...	8.1	4.4	6.93	9.6	5.17	3.52	4.51	2.75	1.48
74 .....	19.3	5.39	3.8	9.6	5.0	8.4	4.62	7.15	9.9	5.28	3.63	4.55	2.8	1.43
Type 76 .....	19.0	5.28	3.8	9.1	5.2	8.3	4.62	6.93	9.9	5.17	3.57	4.51	2.97	1.32
77 .....	18.9	5.39	3.8	9.3	5.1	8.2	4.4	6.82	9.7	5.17	3.63	4.56	2.86	1.37
80 .....	18.8	5.28	3.8	9.4	5.2	8.1	4.4	6.82	9.6	5.17	3.63	4.62	2.97	1.43
83 .....	19.0	5.5	3.8	9.2	5.1	8.4	4.62	7.2	9.9	5.39	3.63	4.62	2.97	1.43
84 .....	19.1	5.28	3.8	9.2	5.2	8.2	4.51	6.93	9.8	5.28	3.63	4.62	2.97	1.43
95 .....	18.6	5.17	3.8	8.9	5.0	8.1	4.4	6.82	9.4	5.17	3.63	4.51	2.86	1.32
100 .....	18.2	5.17	3.5	9.0	5.0	7.8	4.29	6.71	9.4	5.17	3.57	4.4	2.75	1.37
101 .....	18.5	5.33	3.7	9.2	5.0	7.9	4.29	6.71	9.6	5.06	3.46	4.67	2.8	1.43
105 .....	18.4	5.39	3.8	9.4	5.0	7.9	4.29	6.6	9.6	5.06	3.52	4.62	2.86	1.32
106 .....	18.6	5.17	3.7	9.1	5.1	7.9	4.4	6.71	9.3	5.17	3.57	4.4	2.86	1.32
<i>S. minutus</i> .														
BUTE.														
No. 2 .....	15.2	4.67	2.7	7.3	3.5	6.5	3.52	5.4	7.3	4.07	2.97	2.97	2.14	0.88
17 .....	15.5	4.18	2.7	7.2	4.0	6.6	3.74	5.61	7.7	4.29	3.08	3.08	2.2	0.88
24 .....	15.2	3.96	2.7	7.2	4.0	6.3	3.52	5.39	7.4	4.07	2.86	2.97	2.14	0.88
25 .....	15.2	3.96	2.8	7.3	4.0	6.3	3.52	5.39	7.4	4.07	2.97	2.97	2.14	0.88
26 .....	15.0	3.96	2.8	7.3	4.0	6.2	3.47	5.8	7.3	4.07	2.86	2.97	2.2	0.88
69 .....	15.3	3.96	2.7	7.1	4.0	6.3	3.52	5.5	7.4	4.07	2.97	3.08	1.98	0.77
ARRAN.														
No. 51 .....	15.9	4.18	2.8	7.1	4.0	6.8	3.85	5.83	7.8	4.18	3.08	3.08	2.2	0.88
59 .....	15.9	4.18	2.8	7.2	4.0	6.6	3.74	5.72	7.8	4.29	3.14	3.08	2.2	0.88
ISLAY.														
No. 85 .....	15.4	...	2.7	7.2	4.0	6.5	3.74	5.61	7.6	4.23	3.08	3.08	2.25	0.94
86 .....	15.6	4.18	2.8	7.3	4.0	6.5	3.74	5.61	7.6	4.18	3.08	3.08	2.31	0.88

\* These measurements were made with an eyepiece micrometer and 5-inch objective, vide Hinton, "British Fossil Shrews," Geol. Mag. n. s., dec. 5, vol. viii. pp. 537 & 538.

*General characters.*—This mouse is a little larger than *E. glareolus*, approaching *E. norvegicus*, but the tail is shorter than in the latter, and about as in *glareolus*; smaller than *E. skomerensis* or *caesarius*. The ears are about as in *E. glareolus*. The hind feet are as in *norvegicus* and *skomerensis*.

*Cranial and dental characters.*—In size the skull is larger than in *E. glareolus* and agrees with that of *norvegicus*. As in the latter form, the jugals are heavy, but the curvature of the zygomatic arches agrees with *glareolus*. The brain-case is very broad and

Text-fig. 137.

Dorsal view and profile of skull of *Evotomys alstoni*. Natural size.

smoothly convex, the temporal ridges being but faintly indicated even in aged skulls: the parietal region is convex in dorsal profile, with the highest point a little behind the middle of the parietals, instead of flattened; these features impart an appearance of relatively greater cranial capacity than is seen in any of the other European species of *Evotomys*. The postorbital (squamosal) processes are not conspicuous. The interorbital region is broad, with a wide shallow median sulcus. The nasals are rounded or slightly and narrowly emarginate behind, ending flush with or slightly behind the ends of the premaxillæ; they are slightly longer than the diastema, expanded in front, their lateral borders slightly but distinctly concave. The rostrum is shallow, as in *E. norvegicus*, its least depth behind the incisors not exceeding the anterior width. The bullæ are nearly as in *norvegicus*. The last upper molar has a third inner fold and fourth inner salient angle—the latter being usually well developed.

The colour is much darker than in *E. skomerensis*, but is very similar to that of *E. glareolus*, being deep russet above; the under side is richly washed with yellowish or buff.

This is an interesting and quite distinct species, recognizable externally by its generally large size combined with small ears and short tail, while in addition its skull characters are quite distinctive. On the whole it makes a nearer approach to *E. norvegicus* than to any other species of *Evotomys*.

Cranial measurements of *Erotomys*.

	Condylar-basal length.	Zygomatic breadth.	Interorbital constriction.	Mastoid breadth.	Occipital depth (median).	Nasal.	Diastema.	Maxillary tooth-row (alveolar).	Mandible.	Mandibular tooth-row (alveolar).	
<i>E. glar. britannicus</i> .											
Chingford, Essex.....	24.2	14.0	3.9	11.2	6.0	6.8	6.5	5.5	14.5	5.1	Aged.
BCTE, No. 27, male .....	23.5	12.8	3.8	11.2	6.0	6.7	6.4	5.4	14.6	5.4	Adult.
<i>E. alstoni</i> .											
MULL, No. 134, male ...	25.3	13.9	3.8	11.5	6.4	7.5	7.1	5.6	15.6	5.4	Aged.
" 135, " ...	25.3	14.3	3.9	12.1	6.6	7.8	7.7	5.7	15.7	5.4	"
" 136, " ...	24.9	14.5	4.1	11.8	6.3	7.3	6.8	5.6	15.3	5.1	"
" 130, female ...	24.1	13.5	3.9	11.4	6.0	6.8	6.3	5.2	15.1	5.4	"
<i>E. norvegicus</i> .											
Hardanger, 5.8.5.2 .....	24.5	13.4	3.8	11.1	6.0	6.9	7.0	5.4	15.3	5.1	Aged.
Bergen, max. (Miller) ...	26.2	14.6	4.0	12.0	6.6	8.0	7.8	5.8	16.0	5.4	Adult.

## MICROTUS AGRESTIS EXSUL Miller. (Text-fig. 138 A.)

## Four, MULL.

## Dimensions:—

			Head & body.	Tail.	Hind foot.	Ear.
No. 139, male, ad.,	21 June 1912.		125	36	19	12
141, " juv.,	27 " "		100	30	18	11
132, female, subad.,	15 " "		115	32	17.5	12
145, " juv.,	3 July "		105	30	18.5	11

## Eight, ARRAN.

No. 41, male, ad.,	2 April 1912.	125	35	19	12
42, " juv.,	3 " "	105	32	19	11
46, " subad.,	4 " "	117	33	19	13
50, " "	5 " "	115	32	18	12
52, " "	6 " "	112	30	19	12
62, " adult,	15 " "	125	36	19	14
43, female, juv.,	3 " "	105	32	19	11
47, " subad.,	4 " "	115	12	19	12

(damaged)

## One, GIGHA.

No. 127, male, adult,	23 May 1912.	125	33	18	12
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## Eight, JURA.

## Dimensions:—

				Head & body.	Tail.	Hind foot.	Ear.
No. 109, male, subad.,	15 May 1912.			115	30	19	13
118, " " "	16 " "			118	31	19	12
116, " " "	17 " "			115	32	20	11.5
114, female, " "	16 " "			120	34	19	12
115, " " "	" " "			115	32	19	12
117, " " "	17 " "			110	30	18	12
119, " adult, " "	" " "			125	35	19	12
124, " subad., 18 " "	" " "			115	32	19	12

For cranial measurements see Table at p. 834.

*M. agrestis exsul* Miller, of which, in addition to the material in the British Museum, we have examined several specimens from North and South Uist, kindly lent by Mr. Eagle Clarke, of the Royal Scottish Museum, Edinburgh, is a thick-coated form with light upper side and flanks, and under side heavily washed with buff. The fur of the back in winter reaches a length of about 12 mm., including the light tips of about 2-3 mm.; the longer hairs reach about 15 mm. We are not able to distinguish the specimens from Mull, Arran, Gigha, and Jura from this subspecies. Those from Mull are practically quite typical.

The following Table shows the character of the anterior upper cheek-tooth in the skulls examined:—

	MULL.	ARRAN.	GIGHA.	JURA.	
4th inner angle quite absent...	...	...	...	1	1
„ represented by microscopic vestige .....	2 juv.	5	1	4	12
„ small but distinct.....	1	4	...	3	8
Specimens examined .....	<u>3</u>	<u>9</u>	<u>1</u>	<u>8</u>	<u>21</u>

Some features of the skull are discussed below in connection with the form living in Islay.

MICROTUS AGRESTIS MACGILLIVRAII. (Text-fig. 138 B.)

Abstract P. Z. S. 1913, p. 18 (April 15).

## Fourteen, ISLAY.

## Dimensions:—

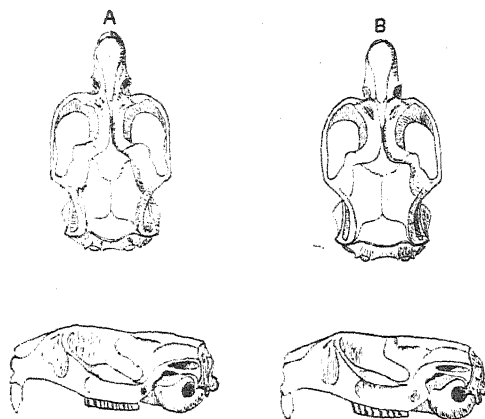
				Head & body.	Tail.	Hind foot.	Ear.
No. 78, male, subad.,	26 April 1912.			115	34	19	13
79, " juv., " " "	" " "			90	27	18	10
88, " adult, 30 " "	" " "			125	40	19	12
89, " subad., " " "	" " "			115	31	19	12
90, " " 2 May " "	" " "			115	37	19	13
102, " adult, 8 " "	" " "			125	32	19	...Type

				Head & body.	Tail.	Hind foot.	Ear.
No. 103,	male,	juv.,	9 May 1912.	105	34	18	11
107,	"	adult,	10 " "	125	37	19	15
159,	"	subad.,	3 August "	110	35	19	12
153,	"	"	7 " "	118	35	18	12
87,	female,	"	30 April "	115	33	19	12
91,	"	adult,	2 May "	120	32	19	13
160,	"	subad.,	3 August "	115	34	19	12
162,	"	"	6 " "	108	33	18	12

For cranial measurements see Table at p. 834.

This mouse resembles *M. agrestis exsul* in size and general proportions, but may be recognized at all seasons by its much thinner coat and the much lesser amount of yellowish wash on the under side, resulting in the slaty bases of the hairs being visible and taking part in the general coloration; the under side thus resembles that of immature *exsul*. The upper side is slightly less brightly coloured than in *exsul*; the hairs of the back reach a length of about 8 mm.

Text-fig. 138.



Dorsal view and profile of skulls of (A) *Microtus agrestis exsul* and (B) *M. a. macgillivraii*. Natural size.

A quite young male (No. 79) is in dusky pelage, with very slight development of the light hair-tips. The hair-tips of the under side are of a very light tint, increasing in depth through the flanks to the back and poll, where they are deepest but never approach the rich buff of adults. The rump of this specimen is more dusky than the back.

In each of the eight skulls examined the anterior upper cheek-

tooth has a distinct and often rather large fourth inner angle. As is usual in microtine subspecies, the subspecific cranial characters first become obvious in old age, although, if care be taken to compare only skulls of equal age, close observation will find the beginnings of such characters in younger stages too. The oldest skull, the type (No. 102), is fairly comparable with that of No. 139, a *M. a. exsul* from Mull, from which it is distinguished by its deeper rostrum, lighter jugals, and more nearly vertical occiput; because the occiput is less sloping the interparietal is a little less reduced,—its posterior border is straight instead of sinuous, and it is rather longer antero-posteriorly. The most striking difference is seen, however, in the form of the "shield" or flattened dorsal area delimited by the temporal ridges upon the sides of the braincase. In *exsul* (text-fig. 138 A) that part of the temporal muscle which arises between the interorbital region and the glenoid articulation continues apparently throughout life to extend its area of origin by creeping up the sides of the braincase and so pushing the temporal ridge backward; the result is that in old age the anterior width of the "shield," taken between its antero-external angles, is considerably less than its glenoid width: in the Islay mouse the upward creeping of the temporal muscle ceases at a relatively early stage of growth, and the result is that in old age the "shield" presents a form which is found only in relatively early stages of development in *exsul*. The oldest skull of *exsul* from South Uist (Edinburgh, No. 300) is younger than the skulls from Islay and Mull just described, the temporal ridges not yet being quite fused in the interorbital region, but the form of the "shield" is already more modified than in the aged type of the present subspecies.

#### MICROTUS AGRESTIS NEGLECTUS Jenyns.

Three, BUTE.

Dimensions:—

	Head & body.	Tail.	Hind foot.	Ear.
No. 67, male, juv., 19 April 1912.....	98	26	17	12
3, female, „ 12 March „ .....	100	26	16	11
64, „ „ 18 April „ .....	95	24	16	11.5

For cranial measurements see Table at p. 834.

The short tails are, no doubt, due to immaturity.

Making allowance for the youth of these specimens, we can detect no character by which the skins or skulls can be differentiated from those of *M. agrestis neglectus* of the mainland.

In his recently published 'Catalogue of the Mammals of Western Europe' (1912), Mr. Miller treats the various *agrestis*-like forms as subspecies. We think it preferable, somewhat as proposed by Barrett-Hamilton in 1896 (P.Z.S. 1896, 19th May, pp. 599-608), to regard these forms as belonging to two species,

a larger northern with isolated southern colonies, now known to be older in western Europe, a smaller southern, now known to be a recent comer. Such an arrangement shows the relationships most clearly. The earliest known member of the group in Europe is a species of which the fossil and fragmentary remains have been found in the early middle pleistocene brickearth of the Thames at Grays in Essex; whether this form has any close affinity with any living now it is impossible to say. In the late pleistocene deposits of Britain, such as that filling the Ightham Fissures, and in many of the caves, remains of a large form not certainly distinguishable, with the available materials, from *M. agrestis neglectus* occur. The Skandinavian *agrestis*, the Hebridean *exsul* and *macgillivraii*, the pleistocene and recent British *neglectus*, together probably with the southern French and Swiss *levernedii*, are all intimately connected forms and may be regarded as subspecies of *M. agrestis*, and of them *macgillivraii* may be counted as the most primitive. At some time since the close of the pleistocene period *M. agrestis neglectus* has been succeeded in England and the lowlands of Scotland by a smaller, brighter form, which being a newer immigrant, may well be granted specific rank as *M. hirtus* Bellamy, with *M. hirtus bailloni* de Selys of France as a subspecies.

Cranial measurements of *Microtus agrestis*.

		Condyle-basal length.	Zygomatic breadth.	Interorbital constriction.	Mastoid breadth.	Occipital depth (median).	Nasal.	Diastema.	Maxillary cheek-teeth (alveolar).
<i>M. a. exsul.</i>									
MULL.	No. 139, male.	28.6	16.2	3.4	12.5	7.1	8.4	8.1	6.9
ARRAN.	43, juv. f.	26.8	15.2	3.4	11.6	6.2	6.8	7.4	6.9
	52, „ „ m.	27.0	15.8	3.5	12.5	6.4	7.5	7.4	7.0
JURA.	119, female	27.3	16.5	3.4	12.5	6.7	7.8	7.5	7.0
N. UIST.	372, „	26.5	14.6	3.3	11.6	6.4	7.5	7.6	6.8
S. UIST.	300, „	27.8	16.3	3.3	12.4	6.8	7.9	7.8	6.5
<i>M. a. macgillivraii.</i>									
ISLAY.	No. 89, male.	26.4	15.3	3.8	12.0	6.7	7.9	7.2	6.6
	78, „ „	26.5	15.3	3.6	11.8	6.2	7.6	7.5	6.7
	103, „ „	26.6	15.4	3.7	12.0	6.2	7.6	7.4	6.8
	87, female.	27.4	16.0	3.7	12.1	6.6	7.9	7.7	6.8
	102, Type ...	28.7	16.4	3.7	12.6	6.7	8.7	7.8	7.1
<i>M. a. neglectus.</i>									
BUTE.	No. 67, juv. m.	24.3	14.0	3.6	11.5	6.0	6.8	6.9	6.1
	3, „ f.	24.4	14.1	3.3	10.8	6.1	6.8	6.8	6.7



## APODEMUS SYLVATICUS SYLVATICUS Linnæus.

Seventeen, BUTE.

No.					Dimensions :—				Skull c.-b. l.
					Head & body.	Tail.	Hind foot.	Ear.	
No. 1,	male,	9 March 1912.			95	78	21	15.7 *	
4,	"	12	"	"	90	80	22.7	15.5	
7,	"	13	"	"	90	80	23	15	22.5
10,	"	16	"	"	90	75	22.5	15 †	22.5
12,	"	17	"	"	90	77	21.7	15	
21,	"	20	"	"	100	86	22.5	15	23.2
23,	"	"	"	"	87	76	22	14	21.5
28,	"	21	"	"	95	85	22.5	15	23.1
31,	"	23	"	"	95	75	22	12.5 ‡	22.0
5, female,	12	"	"	"	80	78	23	14.5	21.5
8,	"	13	"	"	88	75	22	14.7	22.2
9,	"	14	"	"	90	75	22.7	13.5	22.4
11,	"	16	"	"	85	73	21	16	21.0
20,	"	20	"	"	90	90	22	15	22.8
22,	"	"	"	"	83	67	20.5	14.5	20.4
29,	"	21	"	"	80	80	21	14.5	21.8
30,	"	22	"	"	80	73	22.3	16	21.6
Average of 17 specimens of both sexes .....					88.7	77.8	22	14.76	

## Six, GREAT CUMBRAE.

No. 33,	male,	27 March 1912.			95	92	23	15	23.4
35,	"	28	"	"	95	90	22	14.5	22.8
36,	"	29	"	"	95	92	23	16	
37,	"	"	"	"	90	88	23	16	
38, female,	"	"	"	"	93	90	23	15	23.2
40,	"	30	"	"	90	90	23	16	22.4
Average of 6 specimens of both sexes .....					93	90.3	22.8	15.4	

A rather rufous series, perhaps due to late winter coat being worn.

## Nine, ARRAN.

No. 44,	male,	3 April 1912.			100	88	24	14.5	
48,	"	4	"	"	105	83	24	15	24.0
49,	"	"	"	"	105	86	23.5	14	
53,	"	6	"	"	100	85	23	14	23.6
54,	"	"	"	"	100	88	23.7	15	
45, female,	3	"	"	"	90	81	24	14	22.6
55,	"	6	"	"	95	85	23.5	15.5	23.4
56,	"	9	"	"	95	...	23	14	24.0
61,	"	11	"	"	95	80	23	14.5 §	23.6
Average of 9 specimens of both sexes .....					98.3	84.5	25.5	14.5	

This series shows a rather large reddish mouse, with a tendency towards the large foot and short ear of *hebridensis*.

\* Trapped on moss-covered bank.

† Trapped in middle of rough pasture.

‡ Trapped in grass near sea-shore.

§ Trapped in heather on side of cliff.

## One, GIGHA.

## Dimensions:—

	Head & body.	Tail.	Hind foot.	Ear.	Skull c.-b. l.
No. 126, female, 22 May 1912.	100	85	22.5	15	

A rather large nursing specimen with dimensions tending towards those of *hebridensis*.

## Ten, ISLAY. (8, Sheppard; 2, Royal Scottish Museum.)

No. 97, male, 3 May 1912.	83	74	23	13	
99, " 7 " "	98	78	23.5	13.5	23.0
93, female, 2 " "	88	80	22	15	22.1
94, " " " "	100	88	23	15	24.1
104, " 9 " "	95	85	22	14	23.7
164, " 7 Aug. "	90	80	22.5	13	
166, " 8 " "	90	75	22	13	
167, " juv. 8 " "	65	64	17	8	

## Royal Scottish Museum:—

No. 397, female, .....	101	85	22	14.5	
398, " .....	95	90	23	15	
Average of 9 adults of both sexes .....	93.3	81.6	22.5	14	

A moderately large mouse, with back heavily washed with black, probably indicating the new summer coat; stomach clear white, and slight trace of yellow collar.

## Three, JURA.

No. 122, male, 18 May 1912.	98	84	24	14.5	
123, " " " "	100	...	22	14.5	23.9
113, female, 16 " "	95	73	22	14.5	23.5
Average of 3 specimens of both sexes .....	97.6	78.5	22.6	14.5	

## Five, MULL.

No. 129, male, 13 June 1912.	95	92	22.5	14	
131, " 15 " "	98	90	24	15	23.2
133, " 18 " "	100	87	22	14	23.8
137, " 20 " "	92	88	24	14.5	
140, " 22 " "	100	80	24	14.5	24.2
Average of 5 males .....	97	87.4	23.2	14.4	

## Four, TIRRE.

No. 146, male, 8 July 1912.	105	88	23.5	13.5	
148, " 10 " "	105	88	24	13	
149, " 12 " "	100	73	23	14	
150, female, 13 " "	100	88	22	13.5	
Average of 4 specimens of both sexes .....	102.5	84.25	23.1	13.5	

Six from Tiree, in Royal Scottish Museum :—

No.	Sex and Date	Head & body.	Tail.	Hind foot.	Ear.
No. 344.	male, 19 Nov. 1906.	80	85	23·5	14
385,	„ 19 Feb. 1907.	95	89	23	15·5
342,	female, 19 Nov. 1906.	86	90	22	14
343,	„ „ „ „	82	85	23	14
345,	„ „ „ „	75	74	21	13
346,	„ „ „ „	82·5	86	23	15
Average of 6 specimens of both sexes .....		83·4	84·8	19·2	14·2
Average of 10 specimens of both sexes .....		92·9	84·5	21·1	13·8

The specimens from Tiree and Mull are, when adult, apparently above the average size, and tend to have the large hind feet and small ears of *hebridensis*. They also approach *hebridensis* in a tendency to have the under side washed with yellow.

Cranial measurements of *Apodemus sylvaticus sylvaticus*.

	Condylar length.	Zygomatic breadth.	Interorbital constriction.	Mastoid breadth.	Depth of brain-case.	Nasals.	Diastruma.	Maxillary cheek-teeth (alveolar).	Mandible.	Mandibular cheek-teeth (alveolar).	
Bute, 21, male .....	23·2	13·0	4·0	11·2	8·0	10·2	6·6	3·9	14·2	3·6	Aged.
„ 28, „ .....	23·1	12·8	3·9	11·2	8·0	9·5	6·7	4·0	14·3	3·8	Adult.
Cumbræ, 38, female.	23·2	13·2	3·8	11·8	8·2	9·2	6·8	3·9	14·5	3·6	Aged.
Arran, 48, male .....	24·0	13·6	4·0	12·0	8·3	9·6	6·8	4·2	14·9	3·7	Adult.
Islay, 94 female .....	24·1	14·0	4·1	11·4	7·8	...	7·0	3·7	14·9	3·7	Aged.
Jura, 123, male .....	23·9	13·0	4·0	11·6	8·2	9·4	7·0	4·0	14·4	3·8	Adult.
Mull, 140, „ .....	24·2	13·0	4·2	11·7	8·1	10·2	7·4	4·1	14·7	3·8	Aged.

We are unable to distinguish the specimens from the islands from *A. sylvaticus sylvaticus* of the mainland. The dimensions recorded above afford an idea of the variability encountered in this form : even allowing for errors on the part of the collector, and for the differing ages of individuals, there seems to be an inherent tendency to vary. On all the islands, except Bute and Great Cumbræ, there is a dimly seen tendency to acquire greater size, larger hind feet, and shorter ears, *i. e.*, a tendency to vary in the same direction as *hebridensis*, as further shown by the specimens from Tiree and Mull, in which the belly tends to be washed with yellowish tints.

## MUS MUSCULUS Linnaeus.

One, THREE.

Dimensions:—

	Head & body.	Tail.	Hind foot.	Ear.
No. 147, male, 10 July 1912...	80	77	18?	11?

An example in the yellowish outdoor pelage. It was trapped in sand-hills.

In conclusion we have to sum up the distributional evidence and offer a few remarks, of a quite tentative character, upon its meaning as it appeals to us at present. Of the shrews, *S. minutus* occurs throughout the Outer and Inner Hebrides, and in the Orkneys, Ireland, and other islands; *S. araneus*, on the other hand, is confined to the mainland, the Inner Hebrides and such islands as Anglesea and Wight; it is represented in Islay by the peculiar *S. grantii* connected morphologically and geographically with the parent form by means of the partially differentiated Jura form. We may therefore perhaps conclude that *S. minutus* was the first form to arrive in this region; but this point is of little importance, because both species have had representatives in Britain from an extremely early period, and the problem before them in the past may have simply resolved itself into a contest of endurance to decide which of them could survive the rigours of the glacial period in the outlying districts. Be this as it may, one fact stands out clearly, that Islay has been separated from the mainland longer than have the other islands of the Inner Hebrides, with Jura approaching it in age. The microtine species lead us to much more definite conclusions. We have in the Inner Hebrides two genera, *Microtus* and *Erotomys*; the former alone, so far as is known, inhabits the Outer Hebrides as well. As is well known, neither genus occurs in Ireland, and *Microtus* alone is met with in the Orkneys. There is a great difference, however, between the Orcadian and the Hebridean species of *Microtus*: the Orcadian forms are members of the *M. arvalis* group, while those of the Hebrides are members of the *M. agrestis* group. Now, at first sight, having regard to the fact that *M. orcadensis* and *M. sandayensis* have a near ally in the Guernsey *M. sarnius* and another in the late pleistocene English *M. corneri*, as well as to the fact that this group is no longer represented on the mainland of Britain, one might feel inclined to look upon the Orcadian fauna as an older one than that of the Hebrides. On the other hand, we have to remember that both the *M. agrestis* group and the genus *Erotomys* appeared in Britain long before any of the other modern groups of Voles. Each is represented in such an early horizon as that marked by the Grays brickearth by a form much like the living ones; while

the *M. arvalis* group in a modern guise does not appear until the late pleistocene era. Secondly, we have to face the remarkable fact that both *E. alstoni* and *M. agrestis exsul*, with its ally *macgillivrayi* from Islay, are most closely related to the Scandinavian species. Moreover, *M. agrestis macgillivrayi* appears to be a little more primitive in its organization than *exsul*; the latter form in turn a little more primitive than true *agrestis*. The interpretation of these peculiar facts which we suggest is that the Hebrides have formed a refuge for some very old mammals; that from the former continuous land area, of which they are now the disconnected remnants, certain of these old mammals were dispersed along former land bridges to Scandinavia. The proximity of the Atlantic would ensure the existence of much milder conditions in the Hebridean area during the glacial period, at whatever moment in pleistocene time that remarkable event transpired, than would be present elsewhere to the east. It will be seen therefore that we are practically in full accord with the views put forward by Mr. L. Stejneger in his very able and suggestive paper "On the origin of the so-called Atlantic Animals and Plants of Western Norway" (Smithsonian Misc. Coll. vol. xlviii. p. 458, 1907). Just as the presence of *S. grantii* implies that Islay was separated from the mainland at an earlier date than were the other islands of the Outer Hebrides, so the existence upon it of *M. agrestis macgillivrayi* and of a distinct subspecies of Stoat, *Mustela erminea vicine* (found in Jura as well), may be taken as evidence that it was detached from the common Hebridean land surface at a relatively early moment.

The early detachment of Islay and its peculiar mammals has an important bearing on the origin of the Irish Fauna. It indicates that Islay and Ireland have not been connected since the genus *Microtus* and *Sorex araneus* reached the Inner Hebrides. And if that were so, the existence of the deep North Channel between Ireland and South Scotland must at the same time have interrupted communications in that direction also. We are thus unable to accept E. R. Alston's suggestion (Fauna of Scotland, 1880, p. 5) that Ireland received its mammals from Southern Scotland, and are forced to derive the Irish Fauna from England and Wales (see Barrett-Hamilton, Clare Island Survey, Mammalia, Proc. Roy. Irish Acad., March 1912).

#### EXPLANATION OF PLATE LXXXIV.

Fig. 1. *Sorex grantii*. Natural size.

2. *Sorex araneus castaneus*. Natural size.

47. Some Miocene Cirripedes of the Genera *Hexelasma* and *Scalpellum* from New Zealand. By THOMAS H. WITHERS, F.G.S.\*

[Received May 6, 1913: Read June 3, 1913.]

(Plates LXXXV. & LXXXVI.† & Text-figures 139, 140.)

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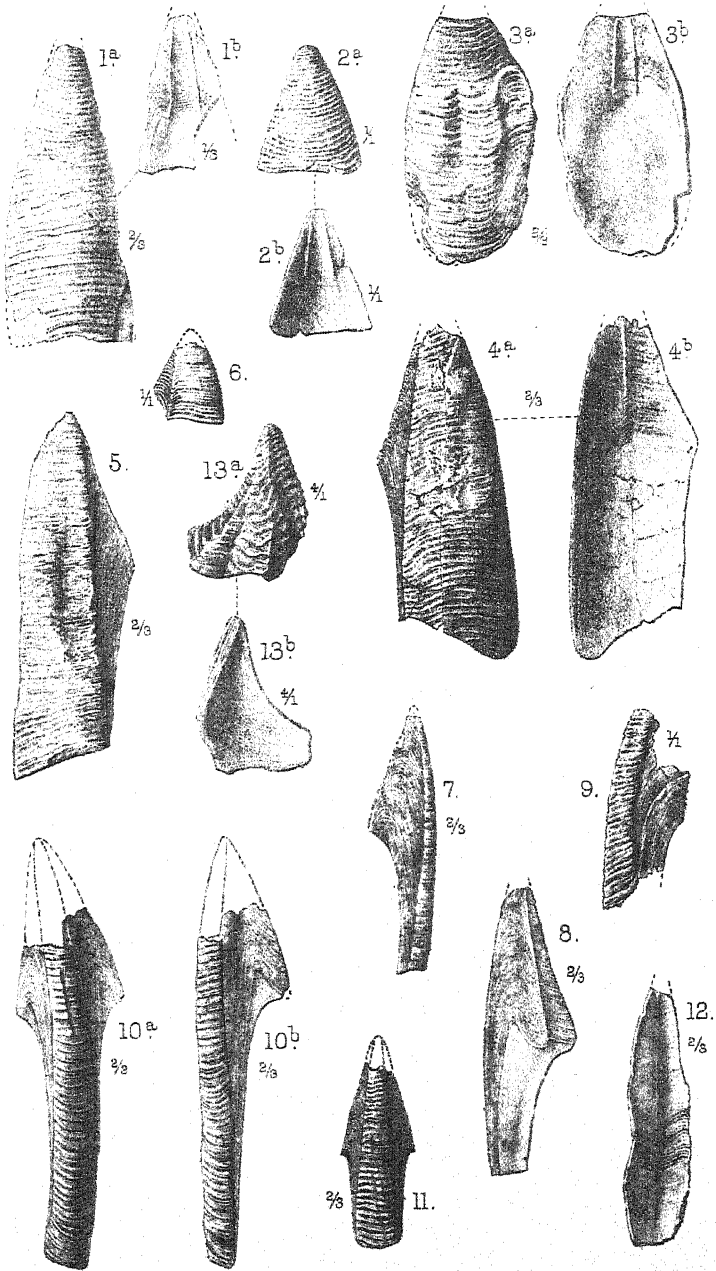
This paper contains the results of a study of the remains of the "gigantic Cirripede" (= *Hexelasma aucklandicum*) from New Zealand, as well as some notes on a smaller species of *Hexelasma*, and descriptions of two new species of *Scalpellum*. One of the latter is founded on some valves in the Geological Department of the British Museum, and the remaining species of *Scalpellum* and the small *Hexelasma* were found associated in the matrix with the remains of *Hexelasma aucklandicum*.

Remains of a gigantic Cirripede have long been known to occur in the Waitemata Beds (Miocene) of Motutapu Island, Auckland Harbour, New Zealand. These remains have been considered by Sir James Hector (1887) and Prof. W. Blaxland Benham (1903) as belonging to a pedunculate Cirripede; but while the former referred them to the genus *Scalpellum*, the latter thought that they approached more closely to the genus *Pollicipes*.

On learning of my wish to see some of these remains, Prof. James Park was good enough to write to Dr. J. Allan Thomson, Paleontologist to the Geological Survey, Dominion Museum, Wellington, who most kindly sent me the actual specimens collected by Prof. Park in 1887. Prof. Park wrote also to Prof. Benham, who sent me plaster-casts of the specimens figured by him in 1903; these casts are now in the Geological Department of the British Museum. My thanks are therefore due to Professors Benham and Park and Dr. J. Allan Thomson, and I have also to acknowledge the kindness of Dr. A. Smith Woodward in allowing me to describe the new species of *Scalpellum* in the Geological Department of the British Museum.

\* Communicated by Dr. W. T. CALMAN, F.Z.S.

† For explanation of the Plates, see p. 854.



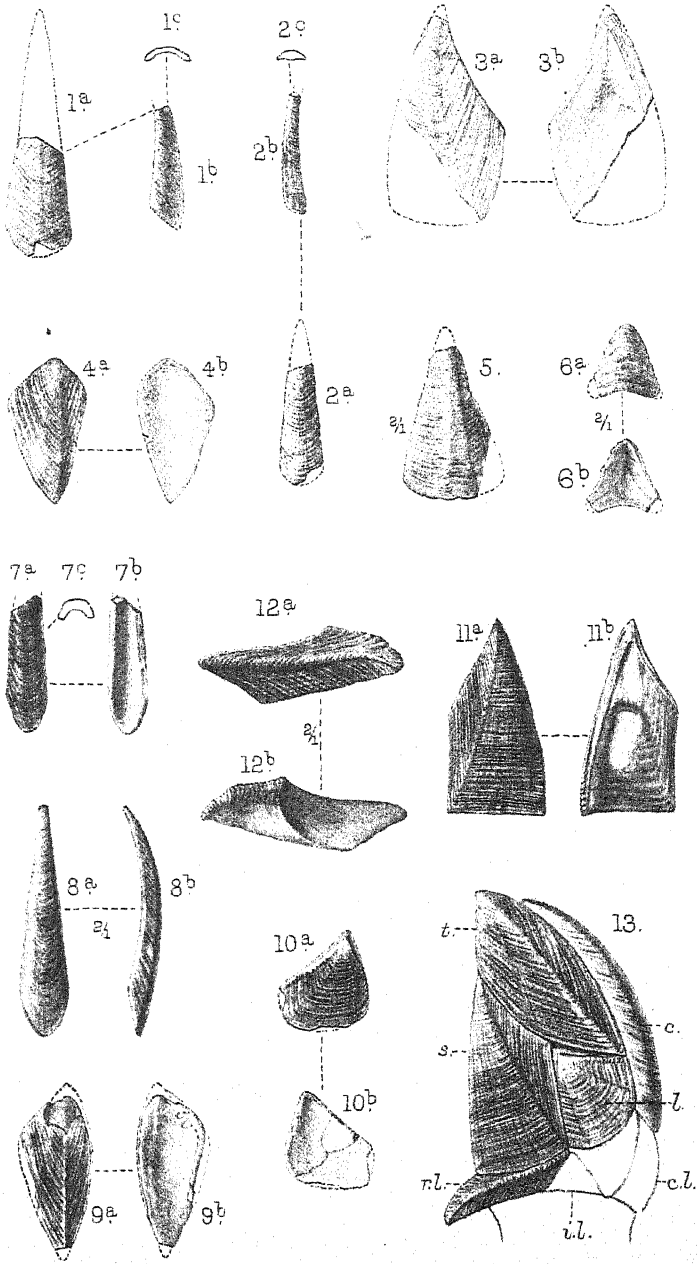
A.H. Seale del. et lith.

Both imp.

HEXELASMA AUCKLANDICUM, *Hector* sp.







A.H. Searle del et lith.

Huth imp.

Fig<sup>s</sup> 1-6. SCALPELLUM SUBPLANUM. sp.n.

Fig<sup>s</sup> 7-13. SARCOSCALPELLUM UNGULATUM. sp.n.



## BALANIDÆ.

## Genus HEXELASMA.

1913. *Hexelasma* P. P. C. Hoek, Siboga-Expeditie, Cirripedia Sessilia, p. 244.

"Compartments six; carina, carino-lateral, and lateral compartments with alæ, but without radii, the rostrum having neither radii nor alæ. Parietes not porose and without longitudinal ribs on their inner surfaces; basis membranous. Opercular valves sub-triangular." . . . P. P. C. Hoek.

## HEXELASMA AUCKLANDICUM Hector sp. (Pl. LXXXV.)

1888. *Scalpellum aucklandicum* Hector, Trans. N.Z. Institute, vol. xx. (1887) p. 440.

1903. *Pollicipes ? aucklandicus* Hector sp.: W. B. Benham, "On some Remains of a Gigantic Fossil Cirripede from the Tertiary Rocks of New Zealand," Geol. Mag. London, dec. 4, vol. x. p. 111, pls. 9, 10 (*non* figs. 8, 9).

1905. *Pollicipes aucklandicus* Benham: E. Clarke, "The Fossils of the Waitemata and Papakura Series," Trans. N.Z. Institute, vol. xxxvii. (1904) p. 419.

1910. *Pollicipes ? aucklandicus* Hector sp.: J. Park, "Geology of New Zealand," p. 115 (pl. 7), pp. 113, 134.

*Diagnosis.* Compartments attaining a length of at least 187 mm., carinal, carino-lateral, and lateral compartments with simple alæ (*i. e.*, there is no distinct upturned extension at the margin). Sheath feebly developed, almost absent, and with no sutural edge to abut against the longitudinal ridge formed on the inner surface. Opercular valves unknown (except for probably a single tergum).

*Material.* 7 rostral compartments, 9 carinal, 13 lateral (8 right and 5 left), 5 carino-lateral (3 right and 2 left), together with a small tergum (Pl. LXXXV. figs. 13 *a, b*), which may or may not belong to the species; all these are more or less imperfect. The specimens are in the collection of the Geol. Surv. New Zealand, and are marked with the locality-number 695. They are presumably the syntypes of Hector. In addition to these specimens I have examined plaster-casts of the specimens figured by Prof. Benham.

*Holotype.* From among the syntypes of Hector I select as holotype the rostrum here figured on Pl. LXXXV. fig. 1.

*Horizon and Locality.* Miocene, Oamaruan, Base of Waitemata Beds: Motutapu Island, Auckland Harbour, New Zealand.

*General Remarks.* Sir James Hector (1887) first called attention to this fossil, and at a meeting of the Wellington Philosophical Institute he remarked on some remains of it there exhibited:—

"Specimens of a large fossil stalked Cirripede, recently

collected by Mr. Park, at Motatapu Island, Auckland. A careful restoration will have to be made before definitely determining this fossil, but it will probably be found to belong to the genus *Scalpellum* and is distinguished provisionally under the name *S. aucklandicum*. In size, this fossil Cirripede greatly exceeds any previously known, in *S. magnum* the capitulum being only  $1\frac{1}{2}$  inches in length, while in the Auckland specimen it is at least 8 inches. These fossils occur in a breccia, marking the old shore line of the upper part of the Waitemata Series, similar to the Cape Rodney beds. The associated fossils are Corals, Brachiopods, and Echinoderms. Among the latter are two specimens having plates of a *Cidaris* of enormous size."

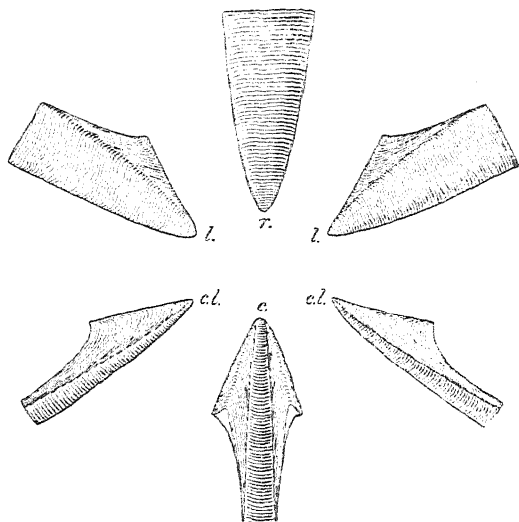
Attention was again called to this fossil in 1903, when Prof. Benham described and figured certain valves. He considered that they showed closer resemblance to the capitular valves of certain species of *Pollicipes*, and doubtfully referred them to that genus.

After an examination of the present material I am convinced that the valves belong to a sessile Cirripede allied to *Balanus*. There are six compartments—a rostrum, carina, right and left lateral, and right and left carino-lateral. Prof. Benham figured only four valves, namely, "a carina, left scutum, ?rostrum, and ?upper latus." The carina figured by him is the same as that now considered as a carina, and the scutum and ?upper latus correspond to the right and left lateral compartments respectively; but the valve figured (Benham, 1903, pl. 10, figs. 8, 9) as a "?rostrum" is really a carina of *Scalpellum subplanum*, sp. n. (see p. 848). The valves considered here as rostral and right and left carino-lateral compartments were not figured by Benham, and it has now been possible to give figures of the inner surface of each different compartment.

*Description of Valves.* Valves with solid walls of variable thickness, apparently not more than 2.25 mm.; externally marked with prominent, more or less regular, transverse growth-ridges, rather more strongly marked on the carina; sometimes ridged longitudinally, and in one or two cases the valves are distorted by linear depressions; but all the valves are more or less irregular in shape, and this is obviously caused by the surface of attachment; inner surface not longitudinally ribbed near the base as in *Balanus*, for the smooth inner surface slopes gradually to meet the outer surface and forms a definite, more or less smooth edge.

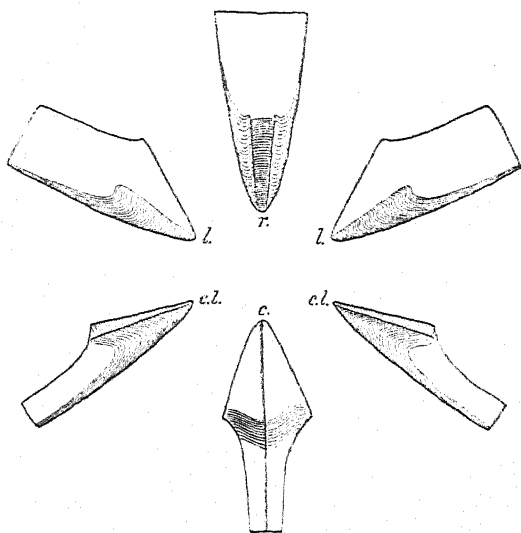
Rostral compartment (Pl. LXXXV. figs. 1-3) without radii, almost symmetrical, moderately convex transversely and slightly convex longitudinally, bluntly angular at the apex, and either rounded or slightly concave at the basal margin; triangular in shape when young, but in the older and consequently longer valves the lateral margins for the greater part are almost parallel to each other. On the inner surface two more or less prominent ridges extend from the apex, and die out at a point halfway from the apex in the young valve (fig. 2) and at a

Text-fig. 139.



OUTER VIEWS.

Text-fig. 140.



INNER VIEWS.

*Hevelasma aucklandicum* Hector sp.

Restored compartments.

r., rostrum; l., lateral; c.l., carino-lateral; c., carina.

point about one-third the length of the valve from the broken apical portions in the larger valves (figs. 1, 3). Obviously these ridges serve for the reception of the angle of the ala on the adjacent lateral valves, and the space between the ridges is marked, in the older specimens, with transverse lines. The portion of the valve enclosed by the ridges is half as wide as the adjacent parts of the valve in the specimen figured (fig. 3 *b*), but in the valves figured (figs. 1 *b*, 2 *b*) it is wider. At the base of the two ridges extending from the apex, and only in the largest valve (fig. 1 *b*), a slight transverse ridge is formed by the thickening of that part of the valve enclosed by the ridges. From a point about one-third from the base of the valve, a small extent of the inner surface, parallel to the outer margins, is marked with lines which extend upward, and bend abruptly inwards towards the base of the ridge on either side; these lines are made by the ala of the lateral compartments which are overlapped by this part of the valve.

Lateral compartment (figs. 4-6) with an ala on the rostral side, moderately convex transversely, and longitudinally almost flat, irregularly convex, and in one case bent in an elongately S-shaped curve; the whole valve is usually strongly bent towards the rostrum, but one valve is strongly bent away from the rostrum. Parietal portion very much wider than in the carino-lateral compartment, as much as three times as wide as the widest part of the ala in one valve, and in others from two to under one and a half times as wide. The two margins of the ala form an obtuse angle, the upper margin is practically straight and the lower somewhat concave, but their shape is influenced by the degree of curvature of the valve; the growth-lines on the ala are closely set and extend obliquely upwards from the base, and on reaching almost to the upper margin curve downwards to the angle of the ala; on the lower margin, near the angle, a small smooth portion is left just below where the growth-lines bend downwards. On the inner surface, almost at the middle of the parietal portion, a more or less prominent ridge extends from the apex and dies out at a point opposite the angle of the ala; near the parietal margin the inner surface is marked with lines which extend upwards, and on reaching a point just above the base of the longitudinal ridge bend sharply inwards and downwards to meet its lower extremity; these lines are obviously made by the ala of the carino-lateral compartment, the angle of which abuts against the longitudinal ridge. Between the longitudinal ridge and the upper margin of the ala the inner surface is marked with indistinct and irregular transverse lines.

Carino-lateral compartment (figs. 7-9) obtusely triangular in general outline, with an ala on the rostral side. The whole valve bent, especially in its apical half, towards the rostrum, is almost flat transversely, and the parietal portion is much narrower than that of the lateral compartment; the two margins of the ala

form an obtuse angle, the upper margin of which is straight and obliquely inclined towards the apex, and the lower margin, which is concave, emerges from just above the base of the valve, and curves gently upwards and then sweeps sharply outwards to meet the upper margin. Parietal portion of valve extremely narrow, the widest part being about one-fourth the width of the widest part of the ala. On the ala the growth-lines are closely set, and follow a similar course to those on the lateral compartment. Beneath the upper half of the ala, a portion of the valve on the inner surface is somewhat thickened for about one-third the width of the valve; its inner margin is steep-sided, and forms a ridge, against which abuts the angle of the ala of the carinal department; the thickened portion of the valve widens gradually from the apex, dies out at a point opposite the angle of the ala, and is marked with fine, regular, closely-set, transverse lines. Near and parallel to the lower half of the parietal margin, and for about one-third the width of the valve, the inner surface is marked with lines which extend upwards, and, on reaching about half the length of the valve, are angularly bent downwards and inwards, and the lowest of them meet the base of the steep-sided ridge near the upper margin of the ala; these lines correspond to, and are obviously made by, the ala of the carina, which are overlapped by the portion of the valve thus marked.

Carinal compartment (figs. 10-12) gently curved longitudinally, with an ala on each side, and these are bent at a sharp angle from the parietal portion. Parietal portion narrow, transversely convex, especially near the apex, much narrower than the parietal portion of the lateral compartment, but wider than that of the carino-lateral compartment; ala about one and a half times as wide as the widest part of the parietal portion, and in one young valve about the same width as the parietal portion. The ala emerge from near the base of the valve, widen gradually upward until about two-thirds the distance from the base, and here they bend further outwards and then sharply upwards to the apex; the two margins, therefore, roughly form an obtuse angle, the basal margin of which is somewhat concave, and the upper margin, which is the shorter, is straight. The growth-lines on the ala extend obliquely upwards from the base and, on reaching a point more than halfway across the ala, bend sharply and angularly downwards to the margin; a smooth triangular portion of the valve is left beneath the angularly bent growth-lines. The inner surface is quite smooth except for some transverse lines, which mark the surface above the angle of the ala and which are more prominent at this point.

*Measurements.* The largest valve in the present series (a carina, fig. 10) would measure, if complete, circa 90 mm., and the smallest valve (a lateral compartment, fig. 6) circa 12 mm. One of the compartments (a lateral) figured by Prof. Benham as a scutum measures 187 mm.

*Structure and Affinities.* It is evident from the structure of the inner surface of the compartments of this Cirripede, and from the modification of the side wall of the compartments to form alæ, that the elements combined to form a shell something like the compartments in the genus *Balanus*. This is proved by the fact that the lines on the inner lateral portions of the rostrum correspond to, and are obviously made by, the growth-lines of the alæ of each lateral compartment, which was overlapped by the lateral portions of the rostrum; similarly shaped lines on the lateral compartment correspond to those on the alæ of each carino-lateral compartment which was overlapped by the lateral compartment; the more angularly bent lines on the carino-lateral compartments correspond to those on the alæ of the carinal compartment which were overlapped by the carino-lateral compartment. In addition, more or less prominent longitudinal ridges are developed in the upper portions of the rostral, lateral, and carino-lateral compartments against which the angle of the alæ of the adjacent valves abutted. The transverse lines on the portions of the compartments not covered by the alæ are similar to those in *Balanus*, in which they are caused by the successive exuviation of the opercular membrane. To a similar cause may be attributed those in the present Cirripede.

That this form is a sessile Cirripede is, I think, beyond doubt, and the irregularity in shape of the several compartments, as well as the fact that some are externally and irregularly ridged longitudinally and others distorted with linear depressions, is further evidence in support of this conclusion, for these features could be caused only by the irregularity in the surface of attachment. In accordance with the above interpretation, six compartments would complete the wall of the shell, as in *Balanus*; and it is important to note that every fragment in the present collection can be allocated to one of the six valves figured. (Pl. LXXXV. & Text-figs. 139, 140.)

The shell of this form could not have been very strong, for, in comparison with the great length attained by the compartments, the walls are relatively quite thin. The compartments could have been only weakly attached, and are in consequence always found quite apart from one another. Moreover, the absence of radii, together with the absence of sutural edges to the alæ and the comparatively feeble ridges or shoulders developed on the inner surface, and against which only the angles of the alæ could have abutted, show quite clearly the great structural frailty of the shell. It could hardly have been a littoral barnacle.

Although this form agrees with the typical species of the genus *Balanus* in the number of compartments forming the walls of the shell, it differs markedly in the structure of these compartments. These differences are (1) the absence of radii, (2) the simpler structure of the alæ, (3) the absence of longitudinal ribs on the inner surface, (4) the feebly developed sheath, as well as the



absence of a sutural edge to abut against the longitudinal ridge on the inner surface. All these are primitive characters, and show that in this Cirripede we have a Balanid more primitive than *Balanus*.

In my preliminary consideration of this form I regarded it as being related, mainly in the absence of radii, to the recent species *Balanus hirsutus* and *B. corolliformis*, which were included by Dr. Hoek \* in a new section (G) of *Balanus*, and *B. hoekianus* and *B. callistoderma*, which were referred by Dr. Pilsbry † to the same section, and I intended to found a new genus to include these species. On seeing a proof of Dr. Hoek's work (1913, 'Siboga-Expeditie, Cirripedia-Sessilia,' pp. 244-246), however, I found that he had included these recent species, together with two new species (*H. velutinum* and *H. arafuræ*), in a new genus *Hexelasma*.

Dr. Hoek kindly sent me drawings of the type-species *H. velutinum*, and from these it could be seen that while *Hexelasma* differs from *Balanus* in the absence of radii and the absence of longitudinal ribs on the inner surface, it agrees in having a well-developed sheath, and in the carino-lateral compartments having an upturned extension of the alæ as well as a well-developed sutural edge.

Since "*Pollicipes* (?) *aucklandicus*" agrees with *Hexelasma* in the absence of radii and of longitudinal ribs on the inner surface, it seems advisable to refer it to that genus; but in some respects it appears to be somewhat more primitive than the typical species of *Hexelasma*, especially in the feeble development of the sheath, in the absence of a distinct upward extension to the alæ of the carino-lateral compartments, and of a sutural edge to the alæ of the carino-lateral compartments.

The species included in *Hexelasma* are all deep-sea forms, and occur at depths varying from about 100 to 900 m. In length the shell of the largest species, *H. corolliforme* Hoek, measures nearly 45 mm., and since the largest-known compartment of the fossil *H. aucklandicum* measures about 190 mm., the great difference in size is apparent.

Except for *Balanus psittacus* Molina sp., which has been known to attain a length of 9 inches (circa 225 mm.), *Hexelasma aucklandicum* is the largest-known Cirripede. *Balanus evermanni* Pilsbry, another large barnacle, is recorded as measuring 150 mm.

#### HEXELASMA sp.

A large number of the disconnected compartments of a small Balanid are to be seen scattered about in the matrix containing

\* 1883. P. P. C. Hoek, 'Challenger' Report, Zoology, vol. viii. pp. 155-160.

† 1911. H. Pilsbry, "Barnacles of Japan and Bering Sea," Bull. Bureau Fisheries, Washington, vol. xxix. 1909, pp. 76-80.

the compartments of *Hexelasma aucklandicum* and the valves of *Scalpellum subplanum*, sp. n. Those that I have been able to extract and clean appear to be somewhat worn, and the largest of them does not measure more than 5 or 6 mm. in length; their outer walls are thrown into comparatively wide longitudinal folds. Owing to their worn appearance the finer characters are not well shown, but since they do not appear to possess radii they must be referred to the genus *Hexelasma*. They differ, however, from the typical species of *Hexelasma*, as well as from the fossil *H. aucklandicum*, in having a well-developed sheath, and in the presence of strong ribs on their inner surface. *Balanus hoekianus* Pilsbry (1911, "Barnacles of Japan and Bering Sea," Bull. Bureau Fisheries, Washington, vol. xxix. 1909, p. 77, text-fig. 8), which has now been referred by Dr. Hoek to his genus *Hexelasma*, agrees with the present compartments in the presence of ribs on the inner surface, but it would be rash to say that they are related specifically. In view of the unsatisfactory preservation of these compartments, and in the absence of the opercular valves, I do not think it advisable to institute a new species.

*Horizon and Locality.* Miocene, Oamaruan, Base of Waitemata Beds; Motutapu Island, Auckland Harbour, New Zealand.

*Collection.* Geol. Surv. New Zealand.

## POLLICIPEDIDÆ.

### Genus SCALPELLUM.

1817. *Scalpellum* Leach, Journ. de Physique, &c., lxxxv. p. 68.

SCALPELLUM SUBPLANUM, sp. n. (Pl. LXXXVI. figs. 1-6.)

1903. *Pollicipes* (?) *aucklandicus* Hector sp.: W. B. Benham, Geol. Mag. dec. 4, vol. x. p. 114, pl. 10, figs. 8-9.

*Diagnosis.* Carina not separated into tectum, parietes, or intraparietes. flatly arched transversely, basal margin bluntly angular; tergum with the upper carinal margin unusually short, and making with the occludent margin an obtuse angle; rostrum with a wide, flat median keel extending from the apex to the basal margin.

*Material.* 2 carinæ, 2 scuta, 4 terga, 1 rostrum, and 1 sub-carina; most of these are incomplete, and they were all extracted from the matrix containing the valves of *Hexelasma aucklandicum*.

*Holotype.* The carina figured on Pl. LXXXVI. fig. 2.

*Collection.* Geol. Surv. New Zealand.

*Horizon and Locality.* Miocene, Oamaruan, Base of Waitemata Beds; Motutapu Island, Auckland Harbour, New Zealand.

Carina not separated into tectum, parietes, and intraparietes, bowed moderately either inwards or outwards, widening gradually

from the apex to the basal margin, which is more or less bluntly angular; flatly arched transversely and indistinctly carinate. The apical portion of the smaller specimen is thickened to quite a third of its extent, the inner portion forming almost a flat surface extending from each side of the carina.

Length (fig. 1, basal half of valve) 16.5 mm.; breadth 10 mm.

Length (fig. 2, basal  $\frac{2}{3}$  of valve) 16.6 mm.; breadth 6.4 mm.

Scutum trapezoidal, nearly twice as long as wide, divided almost equally by an indistinct, flat, wide ridge extending from the apex to the basi-lateral angle. Occludent margin convex; basal margin almost straight. Tergal margin slightly concave, of about the same length as the convex lateral margin, with which it forms an obtuse angle. Along the tergal margin the valve is rounded towards the inner surface. The inner occludent edge is broad, flat, of about the same width throughout, marked with growth-lines, and overhangs the depression for the adductor scutorum opposite the tergo-lateral angle; the inwardly rounded tergal edge is marked with growth-lines, but the extent thus marked narrows rapidly towards the tergo-lateral angle.

Length (fig. 3, incomplete valve) 28.7 mm.; breadth 17 mm.

Tergum subrhomboidal, with an obscure ridge extending in a straight line from the apex to the basal angle, and dividing the valve unequally, the occludent portion being in its widest part almost twice as wide as that of the carinal portion; lower carinal margin weakly convex, somewhat longer than the scutal margin, and forming with it an acute angle; upper carinal margin slightly convex, unusually short, and forming an obtuse angle with the slightly convex occludent margin, which is almost twice its length. The occludent margin forms a somewhat raised border, and this is followed by a wide, shallow depression bounded by an obscure ridge extending from the apex to a point on the scutal margin, which is slightly produced about one-third the distance from the basal angle; from this ridge the valve slopes upwards towards the apico-basal ridge, and slopes rapidly down to the carinal margin. On the inner surface a narrow portion of the valve along the occludent and upper carinal margins is marked with growth-lines, and the extent thus marked is wider beneath the apex.

Length (fig. 4) 20 mm.; breadth 12.4 mm.

Rostrum subtriangular, strongly convex transversely, bowed inwards, basal margin convex; lateral margins slightly concave; a flat submedian keel extends from the apex to the basal margin, and this on the right side is followed by a further longitudinal ridge near the lateral margin, but on the wider left side this ridge, if present, is extremely obscure.

Length (fig. 5) 10.5 mm.; breadth (when complete) circa 8 mm.

Subcarina triangular, moderately convex transversely, bowed inwards; apex rounded; basal margin concave; lateral margins slightly concave. On the inner surface a slight, but well-defined

ridge extends from the apex to about the middle of the valve, and is there met by two further ridges extending from each basal angle: the valve is thus divided into three almost equal portions, the basal one being smooth and doubtless covered at one time by the corium, the two upper portions being marked with growth-lines and most probably overlapping the adjoining carino-lateral valve on either side.

Length (fig. 6) 5 mm.; breadth 5.2 mm.

*Comparison with other Species.* This species is referred to the genus *Scalpellum* (*sensu lato*), a course that is advisable until we can find the remaining valves of the capitulum, which may enable us to refer the species to one of the subgenera into which *Scalpellum* has been divided. Judging from the known valves (carina, scutum, tergum, rostrum, and subcarina), this species is related to *S. zancleanum* Seguenza \* from the Pliocene of Messina, Sicily. The carina of *S. zancleanum* differs in having a strong median keel, from which the sides of the valve slope steeply, and in the less angular growth-lines; the scuta differs in the rounded basal margin and in the usually less acute tergo-lateral angle; the terga differ in being much narrower in proportion to width, in the much more acute apical portion, and in the carinal margin not being divided into an upper and a lower portion; the rostrum differs in the absence of a wide, flat, median keel.

#### Subgenus ARCOSCALPELLUM.

- 1907 (Oct.). *Arcoscalpellum* P. P. C. Hoek, Siboga-Expeditie, Cirripedia Pedunculata, p. 59.  
 1907 (Nov.). *Holoscalspellum* H. A. Pilsbry, Bull. No. 60, U.S. Nat. Mus. p. 25.  
 1908. *Arcoscalpellum* Hoek; H. A. Pilsbry, Proc. Acad. Nat. Sci. Philadelphia, p. 109.  
 1912. *Arcoscalpellum* Hoek; T. H. Withers, Proc. Zool. Soc. London, p. 538.

SCALPELLUM (ARCOSCALPELLUM) UNGULATUM, sp. n. (Pl. LXXXVI. figs. 7-13.)

*Diagnosis.* Carina with its tectum almost flat, parietes more than half the width of the tectum, intraparietes narrow and bent abruptly inwards, basal margin rounded; upper latera subtriangular, with rounded basal margin and wide lateral portions obliquely inclined towards the umbo; rostral latus with subparallel scutal and basal margins, and about one-third of its apical end, which is much thickened, projecting freely beyond the scuta.

\* 1876. G. Seguenza, Atti Accad. Pontaniana, vol. x, p. 386, pl. vii, figs. 1-13.

*Material.* 6 carinae, 4 scuta, 2 terga, 1 upper latus, and 1 rostral latus.

*Holotype.* The carina, I. 15409 (fig. 8).

*Collection.* Brit. Mus. (Nat. Hist.).

*Horizon and Locality.* Miocene, Upper Oamaruan. Blue Clay: Pareora, South Canterbury, New Zealand. Limestone: Takiroa, Oamaru District, N. Otago, New Zealand.

In the Geological Department of the British Museum there is a series of 14 valves of a species of *Scalpellum* (*sensu lato*), registered I. 15409–I. 15422. Although these come from different localities, they are of interest, since they appear to represent a single new species and enable us to gain some idea of the form of the capitulum (see restoration, fig. 13).

Three of the valves (a carina, scutum, and rostral latus) are labelled "*Scalpellum* | (Blue Clay) | Parimoa, New Zealand | Mr. C. Mantell." The remaining eleven valves (5 carinae, 3 scuta, 2 terga, and 1 upper latus) are labelled "*Scalpellum* | Takiroa, New Zealand | Mr. C. Mantell." With the latter series is a MS. label (probably written by the collector) bearing the words "Limestone | Takiroa—Crinoline Qu. 1852."

It is fairly obvious that the "Mr. C. Mantell" was intended for the late Hon. Walter Mantell, from whom a collection of New Zealand fossils was obtained by the British Museum in 1856. On failing to trace the above-mentioned localities, I wrote to Prof. James Park, who kindly informed me that "Parimoa" should be Pareora, South Canterbury, and Takiroa is in the Oamaru District, N. Otago; he was of the opinion that the Cirripede valves came from beds of Miocene (Upper Oamaruan) age. "Crinoline Qu." may mean Crinoline Quarry.

*Description of Valves.* Valves thick, ornamented exteriorly with numerous exceedingly fine ridges radiating from their apices.

Carina narrow, widening very gradually from the apex, moderately bowed inwards, basal margin rounded. Tectum almost flat transversely, not carinate. Parietes more than half the width of the tectum (in one old specimen nearly as wide), bent nearly at right angles to the tectum. Intraparietes very narrow, bent abruptly inwards and meeting just below the apex, so that a small portion of the valve projected freely. Umbo apical.

Length (fig. 7, incomplete valve) 19.2 mm.; breadth 6.5 mm.

Length (fig. 8, small complete valve) 16 mm.; breadth 3.7 mm.

Scutum trapezoidal, almost twice as long as wide; basal and lateral margins slightly concave, nearly at right angles to each other; tergo-lateral angle reaching a point a little above the middle of the valve; tergal margin straight and its outer edge flat; tergo-lateral portion of valve slightly concave; occludent margin moderately convex and very obliquely inclined towards the terga. Umbo apical.

Length (fig. 11) 27.4 mm.; breadth 15 mm.

Tergum subtriangular, convex transversely, thick, elongated, with a prominent, nearly straight ridge, extending from the apex to the basal angle. On both sides of this ridge the valve slopes rapidly to the outer margins. Carinal margin gently convex; ocelludent margin gently convex, with a raised border, followed by a wide depression, extending from the apex to about half the width of the scutal margin, which is indented to that extent.

Length (fig. 9, incomplete valve) 21.4 mm.; breadth 10.8 mm.

Upper latus subtriangular, thick, convex transversely and longitudinally; umbo a little below the apex, owing to a thick ledge formed beneath it, which extends from the lateral angles to just beyond the umbo. Scutal margin slightly convex, its upper surface forming a prominent ridge, followed by a wide depression, which is bounded by an indistinct ridge, and between these two ridges the growth-lines are abruptly upturned; a second indistinct ridge runs almost parallel to the slightly convex tergal margin, and between these the growth-lines are also abruptly upturned.

Length (fig. 10) 15.4 mm.; breadth 13.5 mm.

Rostral latus about four times as wide as long, with a prominent, rounded, wide ridge extending its whole length, from which the surface of the valve slopes rapidly; outer (rostral) extremity bluntly angular, much thickened, and this must have projected freely more than one-third the extent of the valve; inner (lateral) extremity obliquely truncated. Scutal margin concave, sloping upwards to the inner margin of the thickened portion, and then descending rapidly in a curve to the umbo; basal margin straight and almost parallel to the inner two-thirds of the scutal margin.

Length (fig. 12) 4.4 mm.; breadth 15.1 mm.

*Remarks and Comparison with other Species.* In a paper by Dr. G. A. Mantell\* (1850, p. 329) a Cirripede from the Ototara Limestone (Miocene, Upper Oamaruan) is recorded as "*Pollicipes*, resembling a Cretaceous species." There is nothing to indicate whether this is the present species or not. The two scuta figured by Zittel† as "*Cirrhipedenschalen*," and recorded from Whaingora and Aotea, North Island, New Zealand, are certainly distinct from the present species. Zittel's figures were subsequently reproduced and recorded as *Scalpellum* sp. by Prof. James Park‡, who considered the specimens to be of Miocene (Upper Oamaruan) age.

\* 1850. G. A. Mantell, "Notice of the Remains of the Dinornis and other Birds and of Fossils and Rock-Specimens, recently collected by Mr. Walter Mantell in the Middle Island of New Zealand: with Additional Notes on the Northern Island. With Note on Fossiliferous Deposits in the Middle Island of New Zealand, by Prof. E. Forbes." Quart. Journ. Geol. Soc. London, vol. vi. pp. 319-343, pls. xxviii, xxix.

† 1885. K. A. Zittel, "Fossile Mollusken und Echinodermen aus Neuseeland," Paläontologie von Neuseeland (Novara-Exped.), Geol. Teil., Bd. i. Abth. 2, pl. ix. figs. 12 a, b.

‡ 1910. J. Park, 'Geology of New Zealand,' p. 141 (pl. xii.), figs. 9 a, b.

From a study of the isolated valves here described, it seems reasonable to suppose that they formed a capitulum just as is shown in the restoration (fig. 13). No examples of the carinal and inframedian latera have yet been found, but doubtless these will prove to be somewhat like the valves diagrammatically indicated in the restoration. The capitulum, as restored, possesses 13 valves, but this number may have been increased to either 14 or 15 by the addition of a rostrum or subcarina, or both. In any case, it is apparent from the structure and disposition of the valves, that the species falls into the group now included in the subgenus *Arcoscalpellum* Hoek.

*Scalpellum* (*A.*) *ungulatum* may be compared with *S. michelottianum* Seguenza\*, from the Pliocene of Messina, Sicily, and *S. quadratum* Dixon† sp., from the Eocene of Bognor, Sussex, but both these species differ in the valves being appreciably thinner.

Although size is often of little account, none of the numerous valves of *S. quadratum* that I have seen are more than half the size of the largest valves of *S. (A.) ungulatum*. The carina of *S. quadratum* differs in having inwardly bent intraparietes, the scutum in having a raised border to the tergal margin, the tergum in the carinal margin being elongately S-shaped and the apical half bent towards the carina, the upper latus in being more symmetrical and proportionally wider, and the rostral latus differs in the absence of the prominent, transverse, rounded ridge or fold and in the outer extremity of the valve being thickened only to a small extent.

In *S. michelottianum* the carina differs in having broad, rounded, longitudinal ridges on the outer margins of the tectum, in the tectum being proportionally much wider and the basal margin less convex, the scutum in having the tergo-lateral portion of the valve markedly convex and rounded inwards at the tergal margin, the tergum in being much thinner and very much flatter transversely and the median longitudinal ridge hardly perceptible, the upper latus in being more triangular in shape and in the absence of a thick ledge formed beneath and beyond the umbo, the rostral latus in having a much smaller extent of the valve thickened at the outer extremity and in the inner extremity not being obliquely truncated.

*S. michelottianum* var. *gassinensis* Alessandri‡ (Pliocene to Miocene) agrees more closely with *S. (A.) ungulatum* in having the basal margin of the carina more strongly convex, but the other characters of this and the remaining valves differ quite as much as the valves of *S. michelottianum* Seguenza.

\* 1876. G. Seguenza, Atti Accad. Pontaniana, vol. x, p. 381, pl. vi. figs. 15-25; p. 464, pl. x. fig. 26.

† 1846. F. Dixon, in J. de C. Sowerby, Min. Conch. vol. vii. pl. 648; 1851. C. Darwin, Pal. Soc. Monogr. Foss. Lepadidae, p. 22, pl. i. fig. 3.

‡ 1906. G. de Alessandri, Palæontogr. Ital. vol. xii. p. 252, pl. xiii. figs. 10-15.

## EXPLANATION OF THE PLATES.

## PLATE LXXXV.

*Hevelasma aucklandicum* Hector sp.

Miocene, Oamaruan, Base of Waitemata Beds: Motutapu Island,  
Auckland Harbour, New Zealand.

- Fig. 1. Rostrum. *a*, outer view; *b*, inner view of apical portion of same.  
 2. Id. *a*, outer view of small example; *b*, inner view of same.  
 3. Id. *a*, outer view; *b*, inner view of same.  
 4. Lateral compartment (right). *a*, outer view; *b*, inner view of same.  
 5. Id. (left). Outer view.  
 6. Id. (right). Outer view of small example.  
 7. Carino-lateral compartment (right). Outer view.  
 8. Id. (right). Inner view.  
 9. Id. (left). Outer view of incomplete example.  
 10. Carina. *a*, outer view; *b*, side view of same.  
 11. Id. Outer view of small complete example.  
 12. Id. Inner view of incomplete example.  
 13. Tergum. Probably of the same species. *a*, outer view; *b*, inner view of same.

All figures reduced to  $\frac{2}{3}$  nat. size, except figs. 2, 6, and 9, which are nat. size, and figs. 13 *a*, *b*, which are  $\times 4$  diam.

## PLATE LXXXVI.

*Scalpellum subplanum*, sp. n.

Miocene, Oamaruan, Base of Waitemata Beds: Motutapu Island,  
Auckland Harbour, New Zealand.

- Fig. 1. Carina. *a*, outer view of basal half of valve; *b*, side view; *c*, transverse section.  
 2. Id. *a*, outer view of basal two-thirds of a smaller valve; *b*, side view; *c*, transverse section.  
 3. Scutum. *a*, outer view of incomplete valve; *b*, inner view of same.  
 4. Tergum. *a*, outer view; *b*, inner view of same.  
 5. Rostrum. Outer view.  
 6. Subcarina. *a*, outer view; *b*, inner view of same.

*Scalpellum (Arcoscalpellum) unguatum*, sp. n.

Miocene, Upper Oamaruan, "Limestone": Takiroa, Oamaru District,  
N. Otago, New Zealand.

- Fig. 7. Carina. *a*, outer view of basal half of valve; *b*, inner view; *c*, transverse section.  
 8. Id. *a*, outer view of small complete valve; *b*, side view.  
 9. Tergum. *a*, outer view; *b*, inner view of same.  
 10. Upper latus. *a*, outer view; *b*, inner view of same.

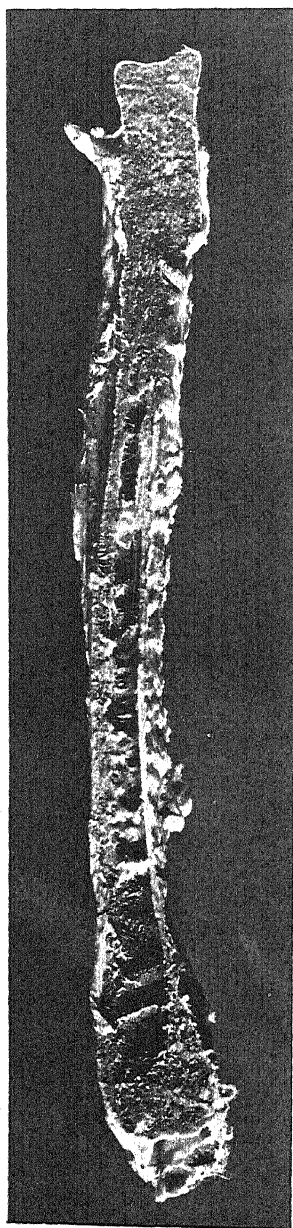
Miocene, Upper Oamaruan, "Blue Clay": Pareora, South Canterbury,  
New Zealand.

11. Scutum. *a*, outer view; *b*, inner view of same.  
 12. Rostral latus. *a*, outer view; *b*, inner view of same.  
 13. Restoration of capitulum, based on the disconnected valves here figured. The inframedian and carinal latera are not known, but these valves have been diagrammatically indicated in the restoration.

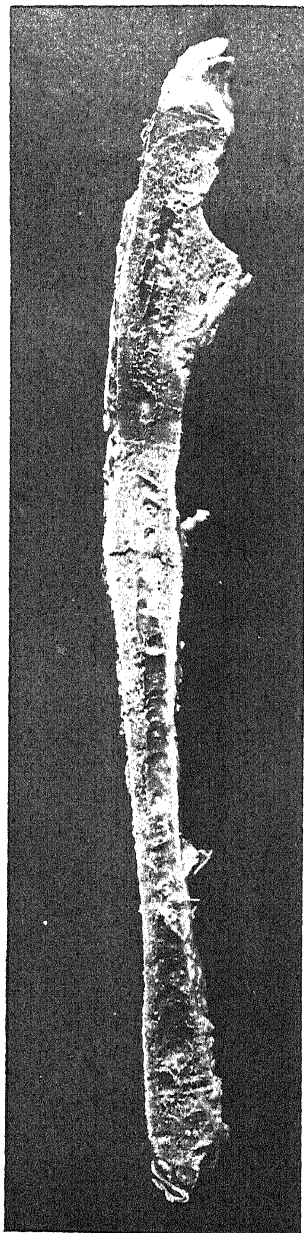
All figures of nat. size, except figs. 5, 6, 8, and 12, which are twice nat. size.







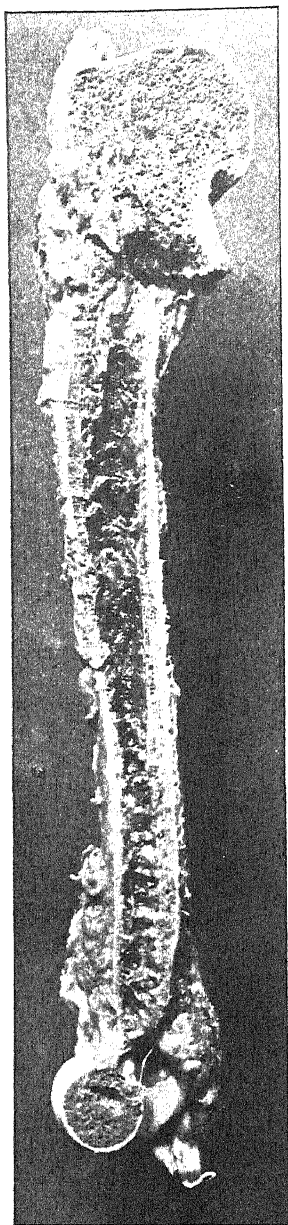
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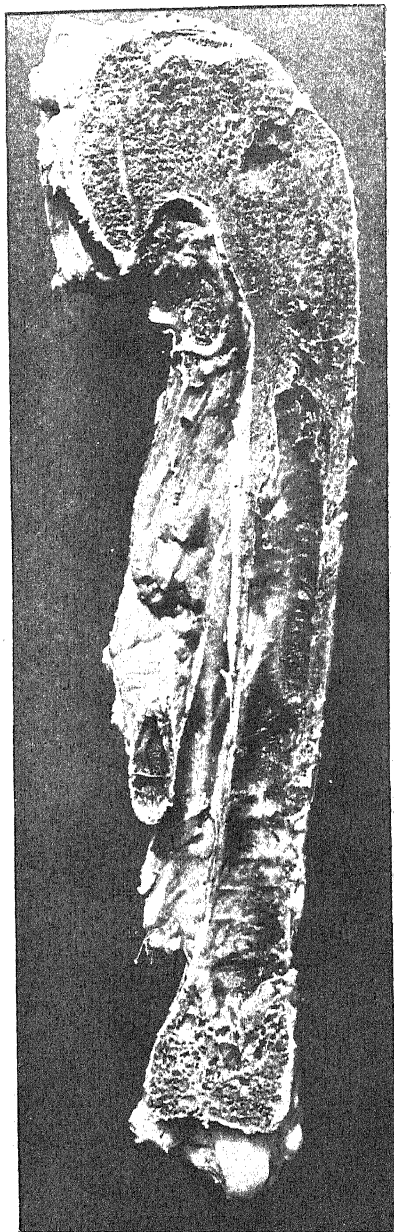
2.

OSTEOMALACIA IN A BABOON.





3.



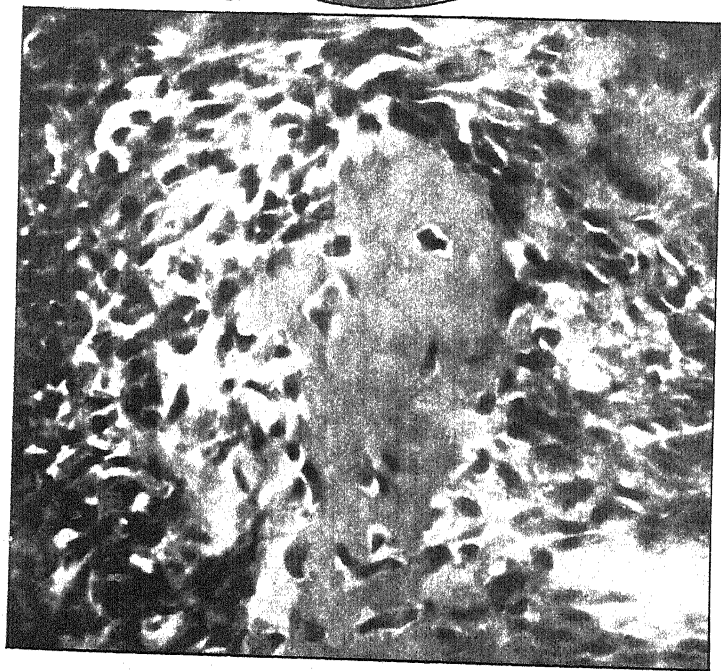
4.

OSTEOMALACIA IN A BABOON.





5.



6.

Bale & Danielsson. L<sup>1</sup> imp.

OSTEOMALACIA IN A BABOON.

48. Observations on Osteomalacia in the Zoological Collections of Manchester and Cleveland. By T. WINGATE TODD, M.B., F.R.C.S., Professor of Anatomy, Western Reserve University, Cleveland, Ohio \*.

[Received May 5, 1913 : Read June 3, 1913.]

(Plates LXXXVII.-LXXXIX.†)

It is the object of this communication to call attention to the widespread appearance of osteomalacia among animals in captivity, and to point out the opportunity afforded by the disease for the study of changes in formed bone-tissue.

Through the kindness of Messrs. Jennison of Manchester and Director Springborn of Cleveland, I have been enabled to study the disease as it exists in the Zoological Gardens of both these cities.

In Manchester, while the cercopitheques, macaques and small baboons were kept in a large cage in a moderately heated monkey-house, the animals sickened and died of miliary tubercle within a few months after their arrival. When, however, the glass was removed from the windows of the monkey-house and a free current of air permitted to pass through the building, the animals remained healthy for as long as three years. Eventually, however, most of them begin to show a disinclination to move about, crouching and walking with the aid of the fore-limbs—the hind ones being curled up beneath the body in squatting attitude. When attacked by healthy animals they seem unable to defend themselves, or, if they try to run away, they do so groaning with apparent pain. This is more marked if they are compelled to use their hind legs, as, for instance, in climbing. Left to themselves they are very much addicted to masturbation. Indeed, in Cleveland, my attention was first drawn to the condition by my being asked to inspect some macaques of both sexes which had developed this objectionable habit. As the disease progresses the joints become stiff and enlarged, although post-mortem joint-changes have not been present in the cases which I have examined. The disease is not of itself fatal and may last two years, although it is usually found necessary to destroy the animals after twelve months. If the animals die, there are frequently indications of broncho-pneumonia found at the autopsy. The food on which all the apes, healthy and diseased, are fed consists of rice-pudding, carrots, onions, potatoes, greens, apples, and bananas, with a little meat occasionally.

While suffering from the disease, the hair may become dry, ruffled, or fall out. This is more frequently the case in rabbits

\* Communicated by the SECRETARY.

† For explanation of the Plates see pp. 859-860.

and rats than in monkeys. The disease seems to localize itself in different sites in different animals. In the macaques and baboons it usually affects the hind limbs, which are in consequence badly bent and twisted, but that the whole skeleton is affected is shown by the brittle character of all the bones. The ability of the bones to unite after fracture does not seem to be impaired. Fig. 4 (Pl. LXXXVIII.) represents the tibia of a young Anubis Baboon (*Cynocephalus anubis*) after healing of a fracture near the upper extremity. This bone was broken by a fall from a height of some three feet while the animal was attempting to escape from a pursuer. The animals may become affected by the disease while still young and before the epiphyses have joined, so that the disease is readily confounded with rickets. The lesions, however, are the same at whatever age the disease occurs. In some instances the bone-changes are found most marked in the fore limbs. This was the case in a peccary from the Manchester Collection. The animal struggled about with its fore limbs bent backwards beneath the body. In other animals the bones of the face are affected. The maxillæ are much enlarged and give a puffed-out appearance to the cheeks. This condition occurred in a horse, a leopard, a rabbit, and a chimpanzee. In some cases the necks of the teeth are decayed and the teeth may fall out. This was observed in the leopard and rabbit just referred to, and also in a Californian sea-lion from Cleveland. Ulceration and falling of the teeth has not occurred among the apes in Manchester since the glass was taken out of the windows of the monkey-house. The bones of the chest are frequently softened and deformed, which would seem to predispose the animal to respiratory disorders. The lungs of the sea-lion showed emphysema and patches of broncho-pneumonia, the latter being confirmed by histological examination.

Post mortem, the viscera show no lesion whatever in animals which have been intentionally killed. Nor are there any atrophic changes in the muscles of the disabled limbs.

The ductless glands are apparently normal. Pathological appearances are to be found only in the nervous system and the bones. As regards the former opinion is very varied. Gayet and Bonnet describe an increase in volume of the nerves with an overgrowth of the fibrous tissue between the nerve-bundles and disappearance of myelin in certain cases. The blood-vessels of the nerves exhibit endarteritis (1). They found no cellular lesion nor any alteration in nerve-fibres in the spinal cord. Morpurgo, on the other hand, describes diffuse chromatolysis in the cells of the anterior horns of the cord, but denies any change in the cells of the spinal ganglia (2). These changes occur very early in the course of the disease, but there would appear to be no definite evidence to show that they initiated the disease (3).

It may be that these different histological pictures were



produced by differences in the aetiology of the disease. For the bone-changes can only be a symptom, caused, perhaps, in many different ways.

The bone-marrow in osteomalacia is much modified. The marrow-cavities of the long bones are enlarged and filled with a gelatinous fatty tissue and by bright red marrow. Marrow is divided microscopically by Ziegler into splenoid and fine-fibred constituent factors (4). Of these the latter form is much increased, partially filling up the marrow-cavity and penetrating the bony tissue.

In early cases the compact bone is invaded by this vascular fibrous tissue, which has already replaced to a large extent the spongy bone and which is not preceded by osteoclasts. The same observation has been recorded by Morpurgo (3).

In later stages the whole of the compact tissue of the shaft has disappeared and is replaced by fibrous tissue, in which are to be found discreet areas or islets of osseous material (see Pl. LXXXIX. figs. 5, 6). There is meanwhile no subperiosteal deposit of new bone. The histological picture of the bone closely resembles that seen in *ostitis fibrosa*. The remaining islets of bone lose their ossein and become transformed into a tissue which, from its staining properties, appears to be hyaline in character. But, at the same time, in other situations the regressing bony substance exhibits a fibrillar change of the ground-substance similar to that described by Retterer as the basis of normal bone (5).

Cells with similar staining reactions to osteoblasts may still be seen bordering the islets of bony tissue (see Pl. LXXXIX. fig. 6). In many places so-called "osteoclasts" are observed. But, on examining several slides one is struck by the comparative infrequency of these cell-masses. As Gayet and Bonnet remark (1) it is difficult to believe that osteoclasts can play more than a very subsidiary part in the destruction of bone, because of their scarcity when compared with the extent of the process. It would appear that osteoclasts are not at all necessary for the production of change in bone-substance.

As the bony tissue becomes transformed or replaced by the fibrous material, the Haversian systems disappear. The periosteum becomes intimately united to the mass of fibrous tissue which remains in place of the true bone. I have not observed hæmorrhages in subperiosteal or other localities. The joints were unaffected. At the diaphyso-epiphyseal junction, changes similar to those in rickets were observed.

The theories of causation of osteomalacia have been well reviewed by Morpurgo (2), who, among others, has succeeded in producing the disease by inoculation of a micro-organism (6).

The detailed histological changes have been discussed by Basset (7), whose description is amply borne out by my own slides.

The disease is one which may be secondary to some other

lesion, and therefore localised, as in the variety appearing after trauma.

It may develop in connection with giant-celled sarcoma and be more generalised in type (Schönenberger, 8).

It may occur in the so-called spontaneous form, such as is seen in animals in captivity.

The last-mentioned variety is certainly not a simple decalcification. There is absorption of osseous substance with rarefaction of the tissue. The process starts from the marrow-cavity and involves first spongy and later compact bone. The Haversian systems disappear and the bone becomes fibrillar in character and later is transformed into fibrous tissue.

An intermediate hyaline change is shown in places. All these changes point to a revolution in the constitution of bone as a whole, which is accompanied by changes in the marrow and periosteum, as already described. Similar changes in bony tissue are to be observed in *ostitis fibrosa* and *leprosy*. For it has been my good fortune to be able to investigate all three diseases at the same time. The clinical symptoms in these cases of generalised bone-softening, which I have described as *osteomalacia*, suggest a nervous origin. The obvious inference to be drawn from the histological picture in *leprosy* is that in the last-named disease the bone-changes are certainly trophic in character. I would emphasise the fact that we are as yet ill-acquainted with the symptoms consequent on lesions to the sympathetic nervous system. But there would seem to be ample confirmation of nerve-lesion in the histological changes found in the nerve-bundles by Gayet and Bonnet (1). Moreover, the intimal proliferation described by these authors in the vessels of the nerve-trunks may be produced by a lesion in the sympathetic nerves, as I have recently been enabled to show (9).

If the disease is infectious, the incubation-period must be considerable, for it seems to appear spontaneously in animals which have been isolated for a long while. After inoculation, Morpurgo found the animal became ill in a week or two. Such evidence as we have points to the nervous system as the seat of primary disease, whether it be infectious or not, and suggests that the bone-changes are consequent on nervous lesion. Treatment is unsatisfactory. Dr. Fox, of Philadelphia, has recently administered calcium lacto-phosphate and adrenalin, separately and in combination, to animals suffering from the disorder in the Philadelphia collection, but without success (10).

In making observations on the living animals Messrs. Antliff and Readinger, keepers of the monkey-houses at Manchester and Cleveland respectively, have rendered generous assistance. The histological sections are the work of Mr. Gooding, of the Anatomical Department of Manchester. Mr. J. C. Miller, of the Laboratory here in Cleveland, has assisted me in gathering and abstracting the literature. To all these gentlemen, I would therefore express my obligation.

*Summary.*

1. Osteomalacia, or so-called spontaneous generalised bone-softening, is not a simple decalcification of bone, but a re-organisation of bone as an organ, in which the loss of osseous tissue is not brought about by osteoclasts.

2. From this it is evident that the cell-masses known by the name of "osteoclasts" are not indispensable in the transformation of bone to less specialised tissue.

3. The disease may be infectious in origin. If so, the evidence at our disposal points to the nervous system as the site of infection. The bone-changes appear to be the symptoms consequent on the nervous lesion.

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EXPLANATION OF THE PLATES.

PLATE LXXXVII.

Fig. 1. Right Radius from young Anubis Baboon (*Cynocephalus anubis*). Advanced stage of osteomalacia.

Note large size and dark colour of marrow cavity. The dark appearance is due to the large quantity of red marrow. The rarefaction of bone and the progression of the osteoporosis from marrow-cavity outwards is well shown in this photograph. The compact tissue can be seen to have been replaced by spongy bone.

Fig. 2. Right Ulna from same animal. Here and there are districts of gelatinous fatty marrow giving rise to lighter areas between the dark-coloured sites of red marrow. The thickened periosteum and its intimate union with the tissue composing the bone can be seen well, especially near the centre of the shaft. In this situation the bone was accidentally broken while stripping off the muscles.

#### PLATE LXXXVIII.

Fig. 3. Right Humerus of same animal.

Note the irregular diaphyso-epiphyseal junction at the upper end of the shaft. The extreme brittleness of the bones resulted in the fracture of the surgical neck of this humerus while the muscles were being removed. There is no sharp line between the articular cartilage of the condyles and the underlying spongy bone. This photograph shows clearly the articular cartilage being destroyed on its bony aspect.

4. Right Tibia and Fibula from same case.

Note extreme recurved upper portion of tibia. The bone had been fractured some time previously and had united in this position. The union is complete. The fibula was likewise bent, its lower extremity is cut obliquely and is shown behind the lower portion of the tibia.

#### PLATE LXXXIX.

Fig. 5. Longitudinal section of shaft of Left Ulna from the same animal.  $\times 40$ .

Note the entire disappearance of Haversian systems from the bone and the replacement of osseous tissue by fibrous material. The bony substance is here shown broken up into islets. The section represents what once was the compact bone layer of the shaft.

6. Longitudinal section of shaft of Left Ulna from the same animal.  $\times 206$ .

A bone-islet is shown surrounded by non-osseous tissue. Note the gradual transition of the bone into fibrous tissue. There is no sharp line of demarcation, and no osteoclasts are to be observed. The decalcification progresses from the centre of the illustration to the periphery. Intermediate between bone and fibrous tissue is a zone where the nuclei are surrounded by considerable non-calcified protoplasm. This corresponds in appearance to the pre-osseous stage in Retterer's description of bone (5).

49. Contributions to the Anatomy and Systematic Arrangement of the Cestoidea. By FRANK E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S., Prosector to the Society.

[Received August 27, 1913: Read October 28, 1913.]

# XI. ON A NEW TAPEWORM FROM *ÆDICNEMUS*.

(Text-figures 141-149.)

## INDEX.

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In Prof. Fuhrmann's exhaustive list of Tapeworms\* (of the Cyclophyllidea only) which occur in birds, only one parasite of this order is recorded from an *Ædinenmus*. The species in question is *Choanotania coronata*, and it occurs in the European *Ædinenmus ædinenmus*. I was, therefore, particularly interested to find in a New World species of the genus, viz. *Ædinenmus bistriatus*, a number of examples of a tapeworm which does not belong to the genus *Choanotania*, though it should probably be referred to the same family and even subfamily.

I shall, however, defer the consideration of the systematic position of this Cestode until an account has been given of its anatomical characters.

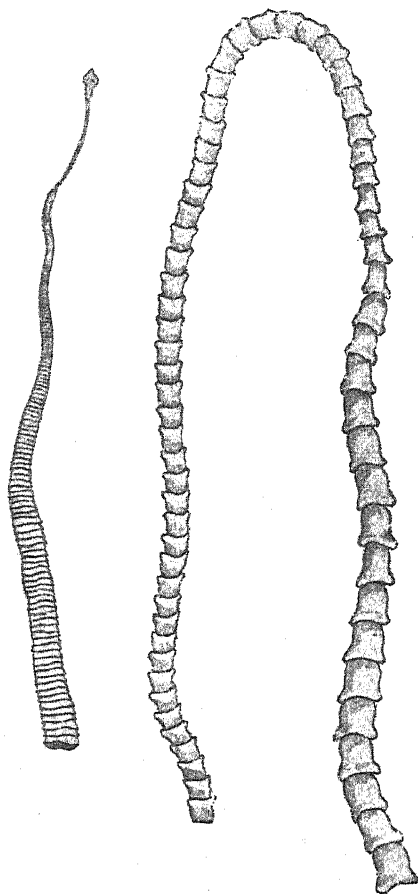
The species dealt with in the present communication was obtained from a Thick-knee of the species mentioned above, which died in April of the present year, and had lived in the Society's Gardens for a year. It is not unlikely, therefore, that the tapeworms had infected the bird before its arrival. But no fact of importance can be at present deduced as to locality, since the very parasite of *Ædinenmus ædinenmus* mentioned above has been also discovered in *Egialitis nivalis*, which is an American bird.

The *Ædinenmus bistriatus* contained no other tapeworms in its intestine, except that which forms the subject of the present communication to the Society. I am not quite certain how many individuals there were; but there were at any rate six or seven. The worms are somewhat slender and measure at least 120 mm. I infer this from the fact that one of the largest fragments, consisting of both ripe and unripe proglottids, measured 110 mm.; but, as it had no scolex nor trace of the thin neck, at least 10 mm. may be added safely. The greatest breadth of the

\* "Die Cestoden der Vögel," Zool. Jahrb. Suppl.-Bd. x., 1908.

ripe protoglottids is 2 mm. The accompanying figure (text-fig. 141) shows the scolex and anterior end of an example of this worm, as well as a portion of the posterior region of the same or of another example. The anterior part of the body shows the

Text-fig. 141.

*Eugonodæum ædicnemis.*

Portions of two examples about twice nat. size.

The left-hand figure shows the rather large scolex and whiplash-like anterior part of strobila. The right-hand figure consists of mature segments.

rather long and oval scolex followed by a slender neck which widens out rather suddenly. Only one specimen out of the six or seven which I have examined showed a gradual increase in

thickness from the neck onwards. This characteristic of the species is not unfrequently met with in tapeworms; it is, however, perhaps unusually strongly marked in this worm from *Edicnemus bistratus*.

The *scolex* is long and oval, and provided with four large suckers which possess no armature of hooks.

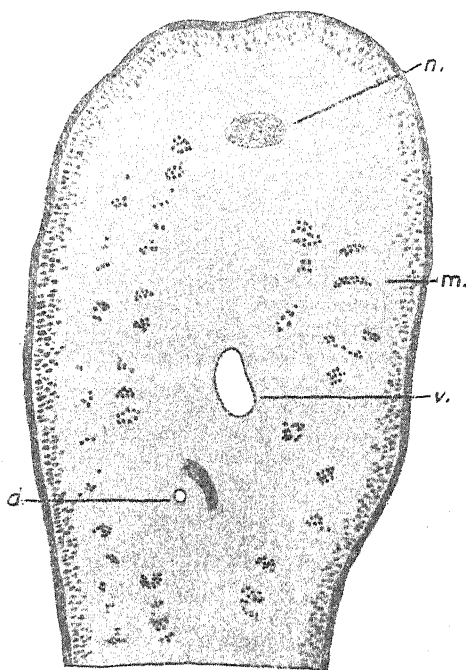
When the *scolex* and the *rostellum* are extended the suckers are quite in contact laterally. They are then oval in form. The *rostellum* is long and retractile; when fully extended it is as long as the rest of the *scolex*. The extremity is entirely muscular with several layers of stout fibres running both transversely and longitudinally. But in spite of its great muscularity there are no hooks. It has been recorded, and I myself have had the opportunity of observing a case, that among tapeworms which possess an armed *rostellum*, the hooks are occasionally absent. But in the present species I have never found them in a single individual. I am thus disposed to think that they are really absent, and to rely upon this as one of the distinguishing characters of the genus, which will be duly set forth later\*. Behind the *scolex* there is quite a distinct neck, in which there is no trace of segmentation to be observed. The segments of the body overlap in the usual fashion and are never greatly elongated. The most posterior are only slightly longer than broad. The last external character to which I draw attention is the position of the *genital pores*, which are unilateral. In the ripe and more elongated segments they lie towards the hinder margin of each proglottid. These orifices are strictly lateral. In the narrow anterior segments the *genital pores* have a peculiar disposition. In horizontal sections through a consecutive series of such proglottids the edges of the proglottids stand out for a considerable distance laterally. The *genital pores* open on these extensions, but on to the anterior margin of each where it runs parallel with the posterior margin of the lateral extension of the proglottid in front. The orifices are thus completely concealed on a lateral view. In more mature segments these lateral extensions do not stand out in the same straight line with the rest of the segment, but become bent backwards; so that the anterior margin becomes lateral.

The structure of a proglottid is illustrated in text-fig. 142 (p. 864). The cortical layer is about as thick as the medullary layer. The former contains two rows of bundles of *longitudinal muscular fibres*; the number of fibres constituting each of the innermost bundles is greater than that of those of the outer. There appear to be a larger number of bundles also in the inner row. These longitudinal muscle-bundles do not extend outside of the nerve-cord; they are not at all closely arranged. The *water-vascular system* consists of two lateral tubes on each side, of which the outermost, or ventral, is several times larger in cross-section

\* *Vide infra*, p. 877.

than the innermost, which I take to be the dorsal vessel. The tubes run nearly parallel to each other: but the dorsal vessel is slightly to the dorsal side of the proglottid. The ventral vessels are connected in each proglottid by a transverse vessel which is shown (in part) in text-fig. 143.

Text-fig. 142.



Part of a transverse section through a proglottid of *Euzonodaeum adicnemii*, to show the arrangement of the water-vascular tubes and of the longitudinal muscles.

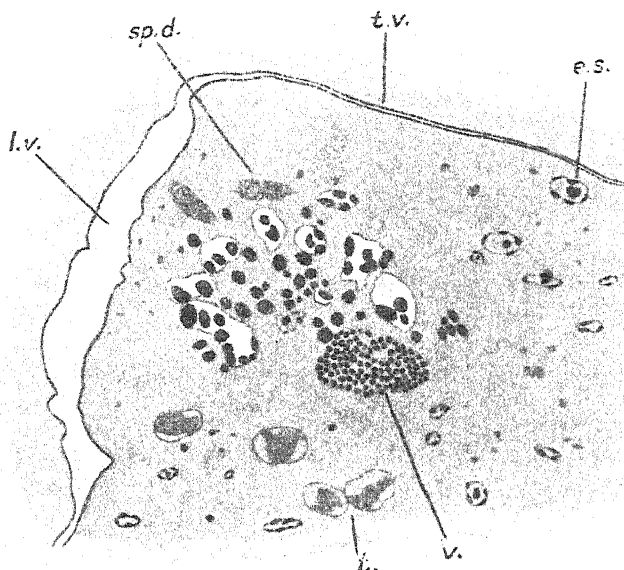
*d.* Dorsal vessel. *m.* Longitudinal muscles. *n.* Nerve-cord. *v.* Ventral vessel.

The *ovary* of this tapeworm is single and not divisible into two lobes, as is so often the case. It lies distinctly to the pore side of each proglottid median of the large (ventral) water-vascular tube and partly ventral, as well as extending to both sides of the dorsal water-vascular tube. It lies in each case anteriorly in the proglottid, and not very far behind the transverse water-vessel of the proglottid in front. In front of the ovary, however, lie some of the coils of the sperm-duct; it is not, therefore, quite at the anterior margin of the segment. The vitelline gland lies behind the ovary and towards its inner (median) side. The relationship is shown in the accompanying drawing (text-fig. 143).



It will also be seen, on an inspection of that figure, that the fully grown ova are largely grouped together in cavities, and that the ovary is more or less hollow. I am not, however, disposed to think that this fact has any morphological significance. Two interpretations are, of course, conceivable. Firstly, that the space is cœlomic, the eggs having been freed from its walls into its cavity. The occurrence of a similar cavity in other tape-worms may perhaps be an argument in favour of this view, which is by no means impossible (and, indeed, has been theoretically demanded by Bergh and others); yet I am disposed to regard the

Text-fig. 143.



Part of a horizontal section through a proglottid of *Eumonodæum ædienemi*.

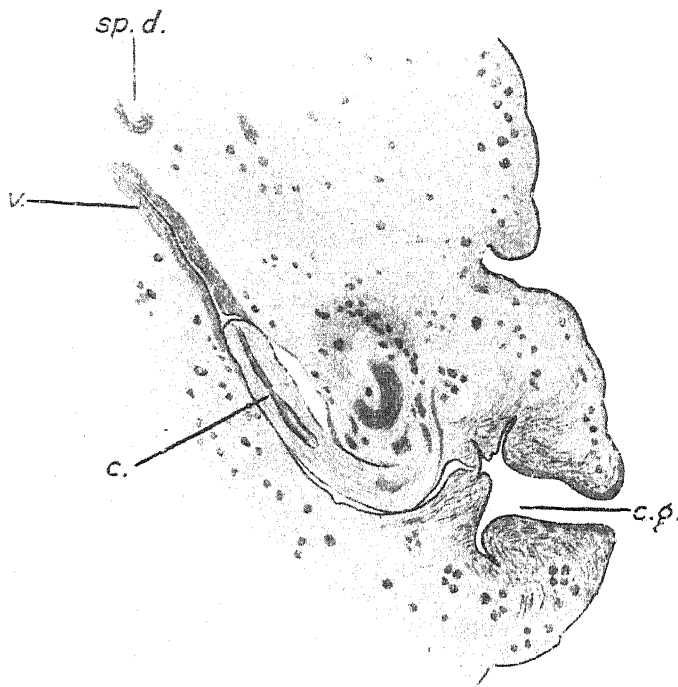
*e.s.* Egg-sacs. *l.v.* Ventral water-vascular tube. *sp.d.* A part of coil of sperm-duct lying in front of ovary. *t.* Testes. *t.v.* Transverse water-vascular tube. *v.* Vitelline gland; in front of this is the ovary, of which the darkly stained mature ova are partly received within cavities of the parenchyma.

cavities as merely due to shrinkage. These hollows might also be considered as the commencement of the uterus. The position, however, would be rather abnormal; and, moreover, as again is insisted upon later in this paper, ripe ova are already scattered through the parenchyma, the cavities surrounding which can therefore have nothing to do with the cavity in the ovary, whatever may be its nature. In younger stages than that which has just been described the ovary forms a quite solid mass. Later on it seems to disappear as a definite structure.

§ *Genital Ducts.*

This worm is characterized by the great depth of the genital atrium, which is much more developed than in most tapeworms and quite as much so as in any. The orifices of these follow in successive proglottids upon the same side of the body. In the ripe proglottids they are situated quite posteriorly and, therefore, the genital ducts which open into them run forwards towards the anterior region of the proglottid. The genital atrium, or genital

Text-fig. 144.



Part of a horizontal section through a proglottid of *Euginodæum ædicnemi*, showing a generative aperture.

*c.* Cirrus extruded from cirrus-sac (shown lying in front of it) and received within vagina (*v.*). *c.g.* Very deep cloaca genitalis. *sp.d.* A coil of sperm-duct.

cloaca, is lined by a prolongation of the outer cuticle; outside of this is a very thick layer of rather stout muscle-fibres which, when the genital cloaca is cut through transversely to its axis, are seen to have a radial arrangement. The cavity is circular in transverse and oblong (more or less) in longitudinal section. At the base, where the genital ducts join it, it widens out and forms

a circular cavity projecting beyond the rest of the genital cloaca. The general shape is suggestive of a silk hat, if the brim of the hat were hollow. From the centre of the lumen of the genital cloaca a slender tube, which from its structure appears to be morphologically a part of the genital cloaca, leads to the junction of the male and female ducts. This is shown in text-fig. 144. It should be noted that the muscular layer of the cloaca genitalis is covered externally by a layer of subcuticular cells continuous with those which underlie the body cuticle. It is, therefore, perhaps to be presumed that the muscular layer in question is a local thickening of the delicate layer of fibres which underlies the body cuticle. Occasionally I have observed the cloaca genitalis to be slightly protruded; in such cases the cavity was more cup-like than cylindrical owing, of course, to the gaping of the external orifice.

The sperm-duct and cirrus-sac, as already mentioned, pass obliquely forwards in the mature segments and are parallel to the vagina, which follows an identical course. The cirrus-sac in this worm is large and directed in a straight line towards its opening into a chamber in common with the vagina. This latter chamber has nothing to do with the terminal cloaca genitalis from which it is sharply marked off by the muscular walls of the cloaca, which have a narrow tube of intercommunication, doubtless capable of being widened. In all the individuals which I examined the cirrus of the fully mature proglottids was largely protruded from the cirrus-sac, but not through the cloaca genitalis to the exterior of the body. I found the cirrus, in fact, to be invariably inserted into the neighbouring vagina, which latter was as invariably filled with spermatozoa. There is, of course, nothing new in this record of self-fertilization, which is well known to occur among Cestodes, and has been recorded by van Beneden, Leuckart, and others. A large number of instances are given in Bronn's 'Klassen und Ordnungen des Thierreichs' by Prof. Max Braun\*. I have not, however, noticed it myself in the considerable number of species which I have examined, excepting in the present species. This auto-copulation is therefore far from being universal in occurrence. It appears to me, furthermore, that the structure of the efferent apparatus in the Cestode, which forms the subject of the present communication, may at times necessitate this auto-copulation. A closure of the cloaca genitalis coinciding with the eversion and protrusion of the cirrus would force the latter into the vagina, which is widened at its extremity, and does not project into the common chamber into which both efferent ducts open†. The passage for the cirrus is therefore not in any way hampered.

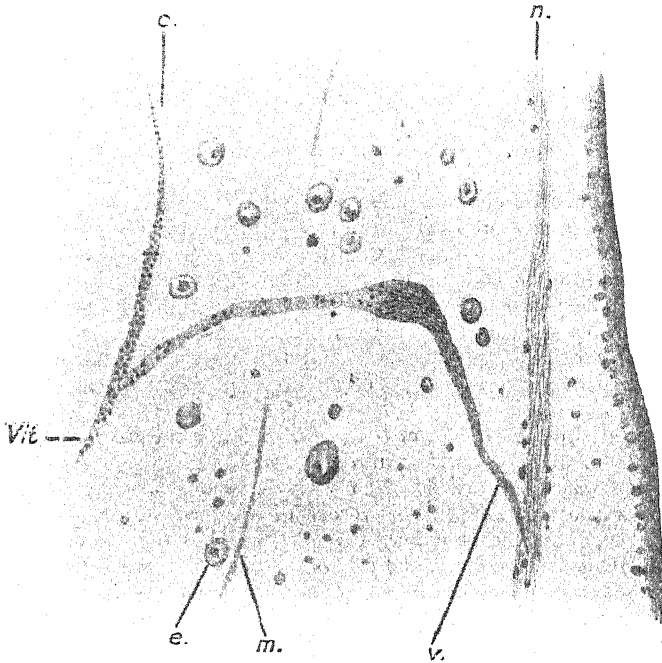
The cirrus-sac has thickened walls, as in so many species, and

\* Bd. iv. Abth. 1, p. 1462.

† v. Janicki in describing *Schizotenia haymanni* (Zeitschr. wiss. Zool. lxxi. 1906, p. 585), where there is also a very deep cloaca genitalis, comments on the mechanical necessity for auto-copulation on rather different grounds.

is somewhat bottle-shaped. The narrow region, however,—the neck of the bottle—is not anterior where the cirrus-sac opens into the common genital atrium, but posteriorly where the sperm-duct opens into it. I have not always seen this narrow backward prolongation of the cirrus-sac; but I have seen it in more than one case. There is no difference in its structure from that of the main part of the cirrus-sac\*. The cirrus, as usual, lies coiled

Text-fig. 145.



Part of a horizontal section through a proglottid of *Eugonodæum cedienemi*, to show further course of vagina.

*e.* Egg-sacs. *m.* Longitudinal muscle-fibres. *n.* Nerve-cord. *v.* Vagina, full of sperm and widening above to form a receptaculum seminis, thence bending back again to divide into the two usual branches *o.* & *Vt.*, which are arranged in the same straight line with each other.

within the sac and when protruded, as shown in text-fig. 144, is broader at the protruded end. This is inserted into the vagina, the proximal dilatation of which it completely fills, as is shown in the same figure. The sperm-duct, after leaving the cirrus-sac, runs in a straight or slightly sinuous course, at first quite parallel

\* It is possibly temporary, and due to unequal contraction.

to the vagina on the anterior side of it. It does not expand anywhere into a vesicula seminalis, but forms a large coil. This coil lies in the neighbourhood of the two water-vascular vessels.

The *vagina* opens behind the cirrus-sac and is wider, and with more muscular walls in that section which lies close to the external pore than elsewhere. It is this region which receives the cirrus during the auto-copulation referred to above. The tube then becomes finer and passes parallel to the sperm-duct, as shown in text-fig. 144. At about the level of the larger, ventral, water-vascular tube it expands into a not very large *receptaculum seminis* (text-fig. 145), which in fully mature proglottids is gorged with sperm. From this point in fully mature segments the vagina then bends back again and divides into two tubes, one running anteriorly and the other posteriorly. In less fully mature proglottids the course of the whole vagina is straight and but slightly oblique, being nearly parallel to the transverse axis of the body. The shell-gland in such segments is very plain.

### § Egg Sacs.

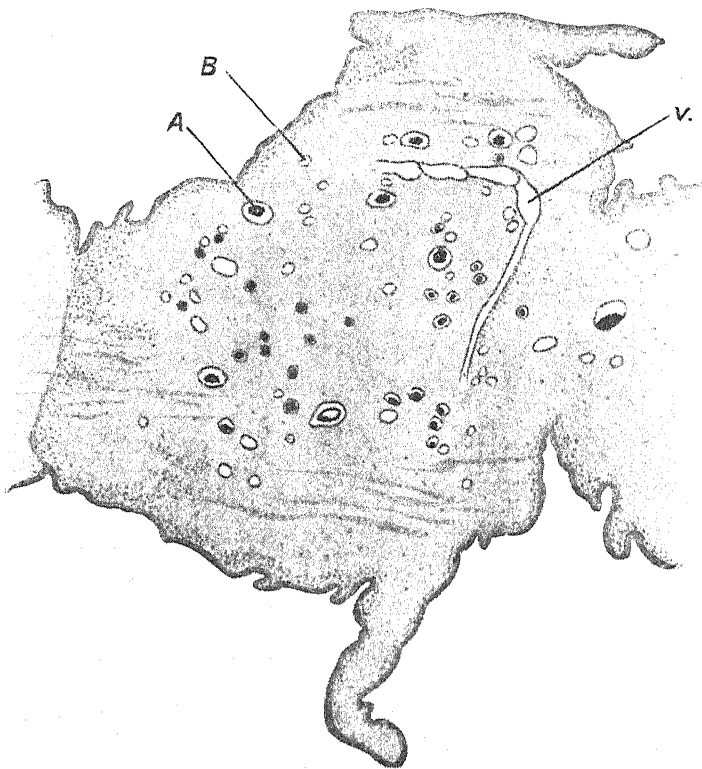
The egg-containing cavities (which do not, as I think, collectively represent a uterus) occur in segments which have already begun to lengthen slightly, although they are still much broader than long. In such segments the ovary and testes are fully mature, but show no signs of degeneration. Several of these egg-holding cavities are displayed in text-fig. 143 (p. 865). They are all small, but not of uniform size; their shape is quite uniformly spherical. There is no regularity of arrangement among them that I can detect; they lie everywhere in the proglottids, even among the bundles of longitudinal muscle-fibres; they thus extend into the cortex, a position which is, however, not unknown in other tapeworms, though it is not common. There is no connection to be observed between adjacent egg-cavities, though they may lie in actual contact: that is to say, there is no question of a network—the cavities are totally independent in fact and, as I shall point out, probably so in origin.

These egg-containing cavities, the largest of which are smaller than the testes, are definitely marked off from the parenchyma, in which they lie, by a thickish wall. The cavity which lodges the egg\* and the vitelline cells is naturally more apparent in the case of the larger sacs. In the smaller ones the egg and accompanying cells fill up the available space completely or nearly completely. The inference appears to me to be that the cavity is formed later perhaps by the exudation of fluid as well as growth of the periphery in a way similar to that of the mammalian Graafian follicle. On the other hand, the structure of the walls of these egg-containing cavities suggests another interpretation. As already mentioned, they are rather thick and thus very conspicuous: in

\* Occasionally two eggs are found in the same cavity.

them occur numerous nuclei sometimes close together and sometimes more sparsely arranged. These nuclei are more numerous in the larger egg-holding spheres, and would thus seem to have multiplied during a growth. But it must be admitted that the existence of sacs with the lining apparently epithelial is highly suggestive of a state of affairs like that shown by *Dipylidium caninum*.

Text-fig. 146.



A horizontal section through mature proglottid of *Egonostomum ardicnem*.

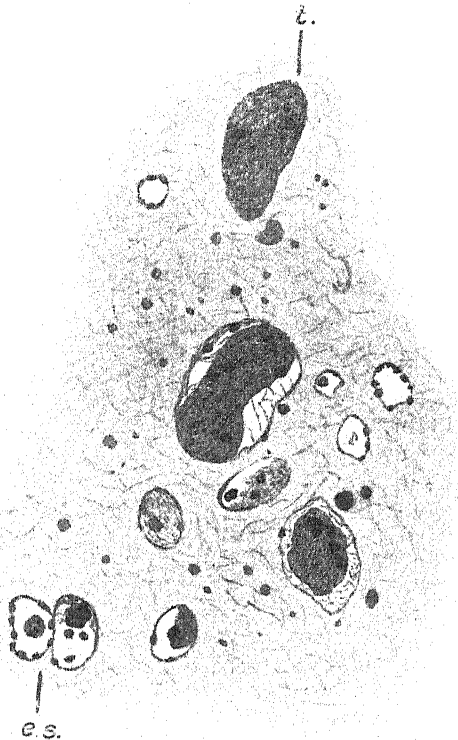
A. Advanced embryo in egg-holding cavity. B. Less advanced embryo in smaller cavity. v. Ventral water-vascular vessel giving off transverse vessel.

In this worm, as is well known\*, the uterus finally breaks up into numerous quite separate cavities, in which lie many ripe ova, and which are lined by a continuous epithelium. The arguments against this supposition, however, outweigh those in

\* Cf. e. g. Beddard, P. Z. S. 1913, p. 555 text-fig. 88.

its favour. In the first place there is no trace that I can discover of a pre-existent uterus\*, whose subsequent fragmentation might produce the result described above. Furthermore, the actual cavities of the egg-holding apparatus are a later development, or at any rate they increase in extent as the eggs within them grow. Indeed it may, I think, be safely asserted that in the youngest

Text-fig. 147.



Part of the section illustrated in text-fig. 146 more highly magnified and showing younger egg-sacs in parenchyma (*e.s.*) and testes (*t.*), which are very much larger.

groups of egg and surrounding cells there is no free space at all. Nevertheless it might be said that all this was due to precocious development, that in fact the rapid protrusion of ripe eggs from the ovary had outstripped the growth of the uterus, which in consequence appeared subsequently in point of time, and that

\* Cf., however, p. 865 under description of ovary.

the uterus for this latter reason appeared in an already divided condition.

It is to be noted that egg-sacs of the character just described occur in the younger proglottids, and that they are also to be found (text-fig. 143, p. 865) in quite young proglottids, in which the ovary and vitelline gland are at their full development and have not commenced to degenerate. Without having any positive proof, I am disposed to think that the cells which encircle the ovum are ovarian or vitelline gland-cells\*, which come to be disposed round the ovum after the fashion of a follicular epithelium in higher animals. It looks to me, in fact, very much as if a ripe ovum with a few adherent cells moved out into the adjacent parenchyma directly from the ovary. There is here clearly a similarity with the Graafian follicle of Vertebrates, a similarity which is even increased by the later appearance of a space (perhaps containing fluid) which surrounds the growing ovum.

It does not always follow that a proglottid which has attained the dimensions and acquired the appearance of a fully mature proglottid should contain only embryos. On the contrary, as be readily seen from an inspection of text-fig. 146 (p. 870), a large flat proglottid, quite as large as it will grow, may have egg-sacs in many stages of growth. In this figure, which is drawn from a section seen under a low power, the size of the egg-sacs is a rough measure of their relative stages of growth. The largest are of course the oldest, and contain fully developed embryos surrounded by a thick shell and enclosed in rather a large space. Intermediate conditions are to be found between this stage and that in which an undivided ovum occupies all the space of the cavity of the body-parenchyma in which it lies. I have also cut sections of apparently fully mature proglottids, in which there were no advanced embryos.

This state of affairs is not unlike what has been described in some other Tapeworms by others as well as by myself. We may exclude *Monopylidium* and *Dipylidium*, which only show an apparent likeness to *Eugonodanum*. In the former genus, and in certain species belonging to the latter genus, the inclusion of the ripe ova singly in compartments of the medullary parenchyma is preceded by a stage in which a functional uterus exists or (*Dipylidium*, various spp.) at any rate a cavity which—full of eggs—is ultimately broken up into single compartments. On the other hand, there is a much greater likeness to *Eugonodanum* in a genus which I have lately described as new under the name of *Diplopylidium*†. Here we have, as it would appear, no trace of a uterus; but the eggs are found scattered widely through the medullary parenchyma enclosed in a cavity singly; the cavity grows in correspondence with the growth of the contained

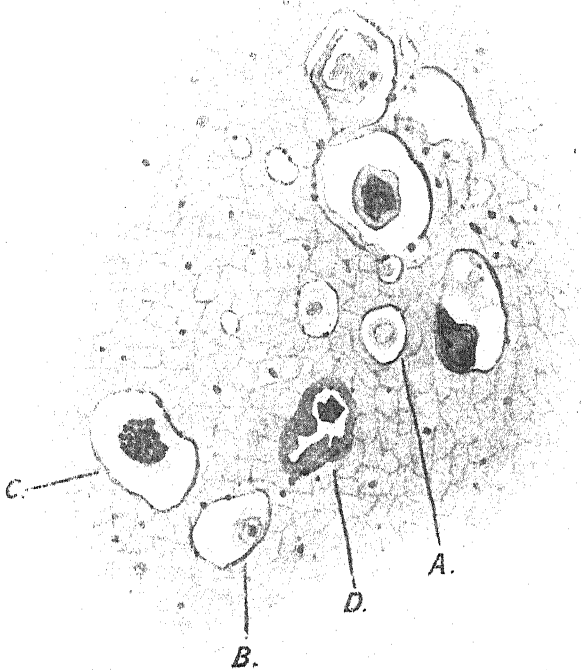
\* Cf. description of ovary and vitelline gland above.

† P. Z. S. 1913, p. 565, text-fig. 93, p. 566, text-fig. 94.



embryo. There is no great difference in size between the egg-holding cavities in the two genera. But there is an important difference in the structure of the wall of these cavities in *Diplopygidium*, and in the presently described genus *Eugonodæum*. In *Diplopygidium* I was unable to find any nuclei lining the cavities, which are simple excavations in the medullary tissue. This was

Text-fig. 148.



Another part of the same section of *Eugonodæum cedrenemi* showing older embryos surrounded by a greater egg-holding cavity in the medullary parenchyma.

- A, B.* Egg surrounded by thick shell and lying in cavity from which nutritive cells (?), such as are shown at *es.* in text-figure 147, have disappeared.  
*C.* Older embryo with larger space surrounding it. *D.* A degenerating (?) egg-holding cavity and embryo.

the case, not only with the fully mature embryos, but also in comparatively newly formed cavities. In *Eugonodæum*, on the other hand, the egg-holding spaces possess a lining of cells. It is true that in fully mature embryo-containing cavities these cells are

often, perhaps generally, indistinguishable. But a granular detritus often visible seems to me to indicate that their tendency to disappear is due to the fact that they serve as nutriment for the growing ovum. It may be noted, furthermore, that the egg-shell in *Eugonodaeum* is not nearly so broad as in *Diplopygidium*.

A resemblance exists between the disposition of the ripe ova in the present genus and that which characterizes *Oochoristica*. I have re-examined examples of a species of *Oochoristica* which I described lately to the Society as a near ally of, if not identical with, *Oochoristica wagneri* of Janicki\*. In the course of my account of that species I figured the scattered condition of the ripe eggs†, well known from the investigations of others to be one of the characters of this genus. I did not, however, attempt any details, merely showing the inclusion of the ripe embryos each in a separate chamber, and these scattered through the general medullary parenchyma. I have now some details to add to that account. The accompanying figure (text-fig. 149) shows a part of a section through one of the last two proglottids of a specimen of this species. It will be seen that the eggs are more closely packed than in *Eugonodaeum*. They are not, however, in contact or enclosed in one cavity. This much concerning the egg-sacs of *Oochoristica* is well known from the observations of several writers previously to myself, *e. g.* Zschokke and v. Janicki. But neither Zschokke‡ nor v. Janicki§ give any detailed figures in their memoirs dealing with *Oochoristica* of the structure of the scattered eggs or oncospheres, or of the spaces which they occupy in the parenchyma. Zschokke describes the three membranes which surround the hexacanth embryos, and observes of them (the embryos) that they "liegen je einzeln in dichtgedrängten, rundlichen, kapselartigen Follikeln des Parenchyms." Cohn|| figures the crowded embryos with their three surrounding membranes entirely filling the proglottids at the end of the body; but he also does not enter into various histological points which are, as I think, of interest in comparing the scattered egg-capsules of *Oochoristica* with those of other tapeworms.

In longitudinal sections of the entire ripe proglottid these egg-capsules are seen to be circular or more oval in contour, and to be larger or smaller in size with no regularity of arrangement. The differences of size correspond as I think partly at least to differences of age. The more or less circular contour may have a relation to the plane of the sections. Contrary to the observations of Zschokke and Cohn upon the species studied by themselves, I can see but one egg-membrane which occupies all the available space in the egg-follicle. V. Janicki gives no

\* Zeitschr. wiss. Zool. lxxxi. 1906, p. 533.

† P. Z. S. 1911, p. 633, text-fig. 150.

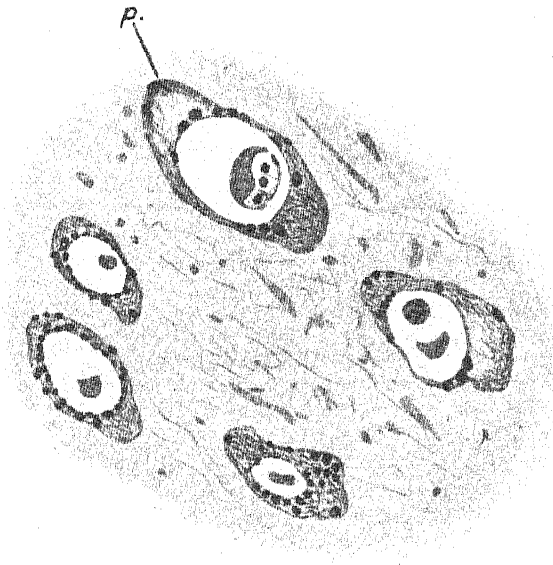
‡ "Das Genus *Oochoristica* Lühe," Zeitschr. wiss. Zool. lxxxiii. 1905, p. 53.

§ *Loc. cit.*

|| Arch. f. Naturg. 1903.

description of the eggs of *Oochoristica wagneri*, which is nearest to, if not identical with, my species, except to state that they are provided with a shell. The sharply defined edge of the shell differentiates the ovum or the cells of the embryo, if it has developed so far, which lie within it from a layer of cells which forms a follicle, and is so far like that which has just been described in *Eugonodæum*. There are, however, differences to be noted which will be apparent from the two figures (text-figs. 148, 149) which illustrate the two species, and which are drawn practically to the same scale. The cells of the egg-follicle in *Oochoristica* have

Text-fig. 149.



A section through a portion of the medullary parenchyma of *Oochoristica*, showing five eggs or developing embryos. *p.* One pole of the usually elliptical embryo-sac.

nuclei of a different appearance and form a thicker layer in that the nuclei are more abundant and closer together. Furthermore, this cellular layer is just as well developed in the largest as in the smallest follicle. The cells do not disappear during the growth of the contained embryo, as would appear to be the case with *Eugonodæum*. It is easy to believe, therefore, in accordance with the opinion of the authors quoted above, that the egg-sacs in *Oochoristica* are portions of a subdivided uterus. I have, however, myself no facts to offer in confirmation of this view.

In many of the egg-follicles the form of the entire follicle is, as already stated, oval. In these cases, which are illustrated in text-fig. 149, the layer of cells extends at the two poles of the ellipse for a considerable distance outwards, and thus a heap of cells is formed. These masses of cells generally enclose a distinct cavity, the function of which arrangement may be to protect the egg from the effect of pressure due to contortions of the worm's body. In any case we have here a state of affairs very unlike that of *Eugonodæum*. It appears to me to be very possible to make a comparison between the egg-sacs of *Oochoristica* and the corresponding structures in two species of *Dacainæa* studied by v. Janicki\*. Referring, for example, to fig. 9 of his memoir, the space lying between the two "Embryonalhülle" at the poles of the elongated embryo might well correspond to the cavity which I describe and figure here in *Oochoristica*. But this comparison, which may be carried a good deal further, is not germane to the object of my present communication, which is to compare *Eugonodæum* with other allied genera.

#### § General Observations.

On the whole the characters of the present species ally it most nearly to the genus *Monopylidium*, the alliance being very largely due to one species only of that genus, viz. *Monopylidium rostellatum*. The genus *Monopylidium* is thus defined by Ransom†:

- (1) Rostellum armed with a double or single crown of hooks.
- (2) A single set of reproductive organs in each segment.
- (3) Genital pores irregularly alternate, rarely unilateral.
- (4) Genital canals pass between the longitudinal excretory vessels and dorsal of the longitudinal nerve, or dorsal of both excretory vessels.
- (5) Testicles numerous (20 to 40 or more), behind the female glands or, also, on both sides of the latter.
- (6) Vas deferens coiled, seminal vesicle absent.
- (7) Uterus breaks down into egg-capsules, each containing one or several eggs.

The worm which forms the subject of the present paper differs from *Monopylidium* in Nos. (1) and (7), and agrees with the genus in the other characters set forth. These differences appear to be quite enough for generic separation were it not for the structure of *Monopylidium rostellatum*. This species has no rostellar hooks, and of the uterus or rather the disposition of the ripe eggs Prof. Fuhrmann writes‡: "Les oncosphères se trouvent réparties dans tout le parenchyme: chacune d'elles est entourée

\* "Ueber zwei neue Arten des Genus *Dacainæa*," Arch. de Parasitologie, vi, 1902, p. 257.

† Bull. U.S. Nat. Mus. No. 69, 1909, p. 76.

‡ "Nouveaux taenias d'Oiseaux," Rev. Suisse Zool. xvi, 1908, p. 65.

par un parenchyme vacuolaire, qui forme autour de l'oncosphère des cellules hexagonales d'un diamètre d'environ 0<sup>m</sup>. 17. Les proglottis mûrs ressemblent ainsi beaucoup à ceux de certains *Dacineæ* à capsules utérines ne contenant qu'un œuf." The difficulty in comparing my genus with this particular *Monopylidium* is that Fuhrmann says very little of a pre-existing uterus.

He merely observes that quite early in the body "l'utérus commence déjà à se former," and that further back "les segments sont remplis d'œufs." I am disposed, however, to think that this implies a likeness to the more typical species—such as, for example, *M. unicolorata*, which Fuhrmann describes immediately after dealing with *M. rostellatum*. Moreover, in his résumé of Avian Cestodes, Fuhrmann\* defines the genus *Monopylidium* by, *inter alia*, the following character:—"Uterus stark verzweigt, löst sich in Parenchymkapseln auf," etc. As *M. rostellatum* had been already described by him it is to be inferred that this species agrees with the others, and is, therefore, so far not like the *Tæniid* which forms the subject of my present communication to the Society. We may, therefore, I think, exclude my species from the genus *Monopylidium*. Nor does it appear to me that we can refer it to any other known species. I propose, therefore, to name and characterize a new genus as follows:—

#### *Eugonodæum*, gen. nov.

*Rostellum* very muscular, long and retractile, without hooks. *Suckers* unarmed. *Ripe proglottids* never much longer than broad. *Dorsal excretory tube* much smaller than ventral, lying more or less laterally to it; *ventral vessels* connected by transverse vessels in each proglottid. *Longitudinal muscles* in two rows of bundles. *Genital pores* unilateral. *Genital ducts* pass between excretory tubes. *Testes* chiefly behind ovary, and then not very numerous. *Ovary* to pore side, in front of vitelline gland. *Genital atrium* very deep, with radiating muscles. *Cirrus-sac* large and muscular, lying in front of vagina. *Sperm-duct* with coil. *Cirrus* unarmed. *Receptaculum seminis* present, but not strongly marked. *Uterus* not present. *Ova* imbedded singly in parenchyma accompanied by other cells; round each ovum a cavity is formed later which is lined by cells.

I name as the type *Eugonodæum ædicnemi*, sp. n., with the characters of the genus.

\* "Die Cestoden der Vögel," Zool. Jahrb. Suppl.-Bd. x. 1908, p. 65.

50. The Brain and Brain-Case of a Fossil Ungulate of the Genus *Anoplotherium*. By R. W. PALMER, M.Sc. (Manchester), Research Fellow in Zoology, University College, Reading\*.

[Received May 29, 1913: Read October 28, 1913.]

(Text-figures 150-157.)

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For some time a cranium from the Phosphorites of Quercy, together with an exceptionally perfect and well-marked brain-cast obtained from it, has been awaiting description in the British Museum. The cast was submitted to Prof. G. Elliot Smith, F.R.S., of Manchester, who intended to describe it, but he was prevented from so doing by the pressure of other work, and very generously passed it, together with the notes he had made on it, to myself. By the courtesy of Drs. Smith Woodward and C. W. Andrews, of the British Museum, I have been allowed to describe both the skull and brain-cast.

The whole of the facial region of the specimen is missing, and since the dentition of mammals forms such an excellent guide to affinities that in original descriptions cranial features are for the most part entirely overlooked, the identification of a toothless skull such as this is a matter of difficulty. A study of the literature of the subject and of such specimens as are available, however, leaves little doubt as to the genus of the creature.

The skull is broken away at the back of the orbits, and the paroccipital, zygomatic, and pterygoid processes are incomplete. In *dorsal view* (text-fig. 150) it is seen to be narrow, elongate, and somewhat fusiform. Its greatest width in front of the zygomatic processes is 49 mm., but behind the orbits it is greatly constricted and its width reduced to less than one half, or 23 mm. At the back of the zygomata, not including the lambdoid ridge, it measures 40 mm. across. The marked postorbital constriction is by no means uncommon in early Tertiary mammals, and indicates at once a poor development of the frontal lobes of the hemispheres.

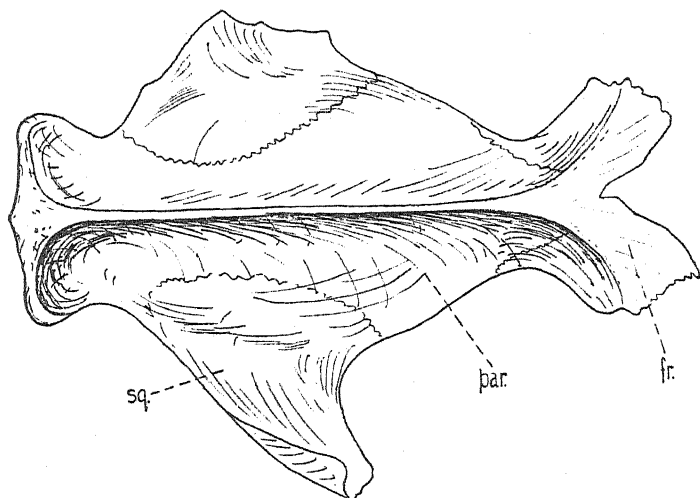
The most striking feature of the dorsal surface of the cranium, however, is the great strength of the sagittal and lambdoid crests. The former arises in front by the union of the two low postorbital ridges on the frontals, and traverses the whole length of the brain-

\* Communicated by Dr. C. W. ANDREWS, F.R.S., F.Z.S.

case as a knife-like ridge which rises as high as 16 mm. above the general surface. As it nears the occiput the crest somewhat thickens and meets the equally highly developed and more massive lambdoid crest at right angles.

The root of the zygomatic process is very extensive and slightly convex antero-posteriorly. Its widely concave form in a transverse direction indicates a temporal arcade standing well out from the skull.

Text-fig. 150.



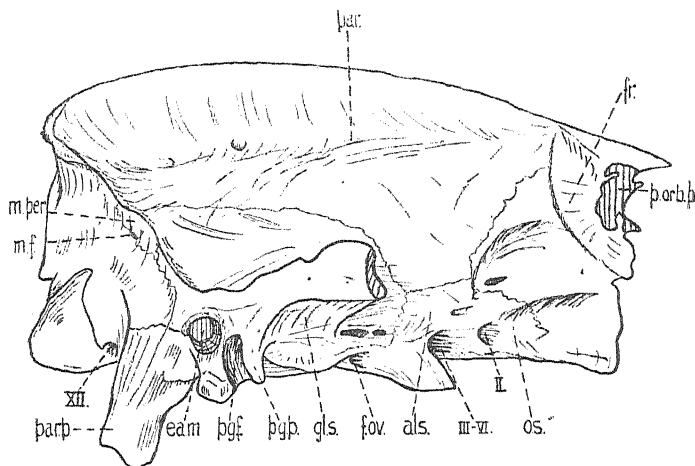
Dorsal view of skull of *Anoplotherium*.

*fr.*, frontal; *par.*, parietal; *sq.*, squamosal.

In *lateral view* (text-fig. 151) the great height of the sagittal and the true form of the lambdoid crests are displayed. This latter strikes off at right angles to the sagittal for about 2 cms., slightly dropping in elevation as it does so, then falling very sharply downwards, forwards, and slightly inwards, is continued as a much less pronounced ridge to the posterior root of the zygoma. Here it bifurcates, the anterior branch being an extension of the vertical flange of the zygomatic process, while the posterior runs down, and slightly back, on to the huge paroccipital process, on which it dies out. The aperture of the external auditory meatus between the paroccipital and zygomatic processes is remarkable in being formed above by a groove in the squamosal, while the tympanic forms its floor alone, there being no ordinary bony tube.

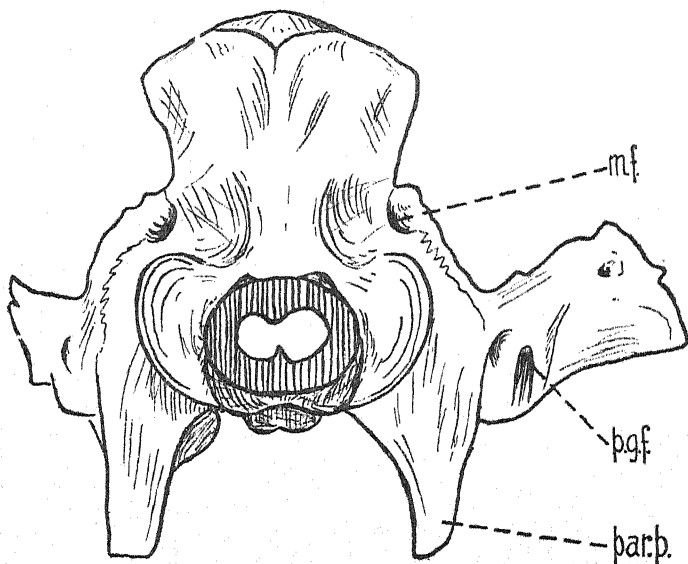
In *occipital view* (text-fig. 152) the foramen magnum is seen to be nearly circular and the condyles massive. Above, the lambdoid crest forms a large shield-shaped area much roughened for

Text-fig. 151.

Lateral view of skull of *Anoplotherium*.

*als.*, alisphenoid; *e.a.m.*, external auditory meatus; *f.ov.*, foramen ovale; *gls.*, glenoid surface of the squamosal; *m.f.*, mastoid foramen; *m.per.*, mastoid portion of petiotic; *os.*, orbitosphenoid; *par.*, parietal; *par.p.*, paroccipital process; *p.g.f.*, post-glenoid foramen; *p.g.p.*, post-glenoid process; *p.orb.p.*, post-orbital process; *II.*, optic foramen; *III-VI.*, united sphenoidal fissure and foramen rotundum; *XII.*, condylar foramen.

Text-fig. 152.

Occipital view of skull of *Anoplotherium*.

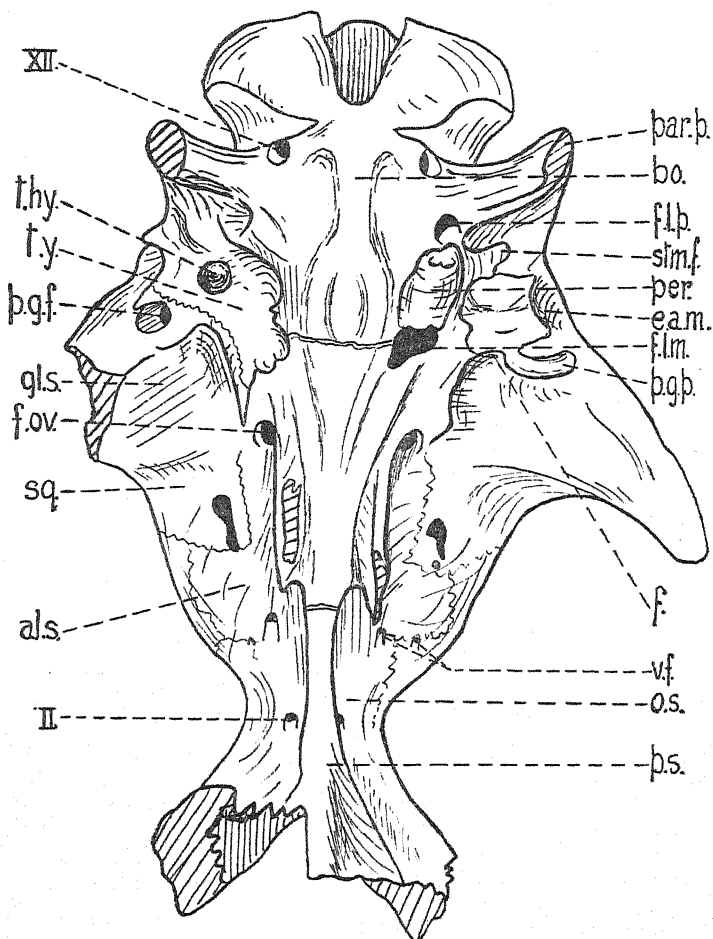
Lettering as in text-fig. 151.



muscular attachments. The paroccipital processes are seen to diverge slightly below.

The *palate* (text-fig. 153) is very long and narrow. The glenoid surfaces of the squamosals are large and flat with strong post-glenoid processes. On the left side the tympanic has been preserved, while on the right this is conveniently missing, leaving

Text-fig. 153.



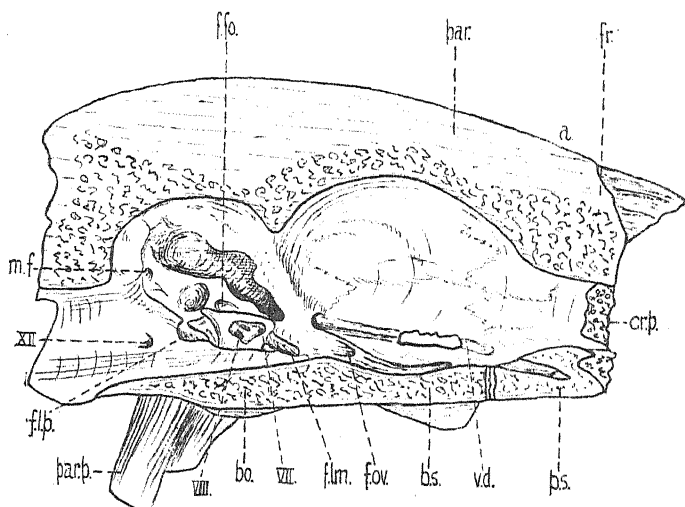
Palatal view of skull of *Anoplotherium*.

Lettering as in text-fig. 151, with addition of *bo.*, basioccipital; *f.*, venous foramen; *f.l.m.*, foramen lacerum medium; *f.l.p.*, foramen lacerum posterius; *per.*, periotic; *p.s.*, presphenoid; *sq.*, squamosal; *st.m.f.*, position of stylomastoid foramen; *t.hy.*, point of attachment of tympano-hyal; *t.y.*, tympanic; *v.f.*, canals for vessels of the diploë.

the lower surface of the periotic exposed. The secondary palate is completely lost.

In a *longitudinal section* of the skull (text-fig. 154) the great thickness of the bones and the general development of diploë are striking features. A skull which supported such massive temporal muscles as this beast possessed had of necessity to be of a strong build. The extreme shallowness of the pituitary fossa and the practical absence of clinoid processes are features of interest, while the mode of attachment of the cribriform mass to a groove in the pre-sphenoid is curious. The pear-shaped cerebral fossa is partly separated from the cerebellar by the heavy tentorial ridge,

Text-fig. 154.



Median section of skull of *Anoplotherium*.

Lettering as in preceding figures, with addition of *b.s.*, basisphenoid; *cr.p.*, cribriform plate; *f.f.*, floreous fossa; *v.d.*, canal for vessel of diploë.

most of which belongs to the squamosal. The spacious cavity for the transverse sinus opens immediately behind this ridge above the periotic. It goes straight down to the post-glenoid foramen and is joined by a canal for a vein which ran in a deep groove on the side-wall of the skull, and was formed by the confluence of two vessels which ran in the substance of the alisphenoid.

The main features of the individual bones of the skull will now be outlined.

The bones of the *occipital segment* are indistinguishably fused together, but their anterior sutures are for the most part distinct. The thick *supraoccipital* is of great extent owing to the extreme development of the lambdoid crest, of which it forms the entire

upper portion. It articulates with the parietals by a jagged transverse suture anterior to this crest. The *exoccipitals* were also large bones, including, as they no doubt did, the large condyles and practically the whole of the paroccipital processes. They take no share in the lambdoid ridge, for their suture with the mastoid and squamosal lies just posterior to this ridge. It is a jagged line, starting at the base of the steep drop in the crest, and, travelling behind it, runs down on to the paroccipital process. The *basioccipital* is clearly marked off from the basisphenoid by a slightly irregular groove. It is very wide behind, between the paroccipital processes, and notched by the condylar foramina which must pierce the skull between it and the exoccipitals (text-fig. 153, p. 881). In front it is narrowed by the lacerate foramina and by the gap in which the periotic is set. Its lower surface is here heavily marked for muscular attachments. In section, the bone is seen to be thin and dense posteriorly, but in front it is thicker and more cancellous in structure (text-fig. 154).

The *parietals* are remarkably extensive, and externally they appear to form the entire cranial roof. Anteriorly, they considerably overlap the frontals, and the extent of this overlap can be seen in section (text-fig. 154), where the junction of the bones is indicated by a break in the structure of the roof (at "a" in the figure). The parietals do not share in the formation of the lambdoid crest, but meet the supraoccipital anterior to it. There is no trace of a distinct interparietal, and the strength of the sagittal ridge has necessitated a firm union of the parietals. The suture with the frontals is first seen as a jagged line on the postorbital ridge. It travels forwards along this for about 12 mm., then turns suddenly backward and curves down on the side of the skull till it strikes the alisphenoid. Below, the parietal is suturally connected with the alisphenoid along a short horizontal line, and posteriorly it is considerably narrowed by its bow-shaped suture with the squamosal (text-fig. 150, p. 879). Inside the skull, the fronto-parietal suture is seen as a very irregular line running vertically on the wall of the cerebral fossa, and the squamoso-parietal suture as an even more irregular line in front of the tentorium. Neither suture can be completely traced.

The *squamosal* forms a considerable part of the side-wall of the skull. Posteriorly it overgrows the mastoid, so that only a small isolated surface of this bone is exposed. The suture with the mastoid is anterior to the lambdoid crest, and as this bone gets submerged the suture crosses the crest to form the junction with the exoccipital. The squamosal sends a small vertical thin flange on to the root of the paroccipital process. It is partly ankylosed with the tympanic, and in front of the meatus is bored by the very large post-glenoid foramen. Almost the whole length of the bone is concerned in forming the zygomatic process, which is concave from side to side above, has a vertical flange to the exterior, and a flat glenoid surface below. The flange is roughened on its upper edge for attachment of the temporal fascia. To the inside

of the glenoid fossa, where the squamosal meets the alisphenoid, there is a narrow ridge which both bones help to form, and which runs parallel to the middle line to separate the glenoid and tympanic cavities. Where this ridge meets the post-glenoid process there is a depression which may represent a venous foramen (text-fig. 153, *f.*, p. 881).

Seen from the inside the *periotic* is quite an extensive bone. The double openings of the internal auditory meatus and of the aqueductus Fallopii are seen in the centre of the lower triangular part. Above this, the floccular fossa (*f.f.*) is excavated, and from this region the large mastoid portion inclines backwards. The mastoid part, as mentioned, is exposed on the outside of the skull only as a small island between the exoccipital and the squamosal, forming the lambdoid crest for about 1.5 cms. Through its suture with the exoccipital runs the small mastoid foramen (*m.f.*). The inferior surface of the petrosal portion is seen as a subovate mass inclined steeply outwards and jammed in between the basioccipital and squamosal. It separates the median and posterior lacerate foramina. Posteriorly it is pierced by the fenestræ rotunda and ovalis.

The *tympanic* is preserved on the left side. It is partly ankylosed to the squamosal, but not to the periotic. It consists of a small, very thick, uninflated bulla which does not meet the basioccipital, but projects freely under the petrosal. A cylindrical hollow on the bone represents the attachment of the tympano-hyal (*t.hy.*), and on the right side the position of the stylomastoid foramen (*stm.f.*) is seen to be immediately behind this. The rest of the bone forms an irregular mass below the meatus and presents no points of interest.

The *alisphenoids* are firmly fused with the *basisphenoid*, and the three bones must be taken together. The basisphenoidal part is very elongated—behind, it is wide and notched by the median lacerate foramina. In front, it narrows very considerably, and at the junction with the alisphenoidal part the vertical pterygoid wings arise. The alisphenoidal part is a hatchet- or L-shaped bone, having a narrow limb confined to the base of the skull between the squamosal and the basisphenoid and a square limb in front of this, forming part of the side wall of the skull and meeting the parietal above and the frontal in front. The long limb is deeply grooved for the Eustachian tube, and in its middle is perforated by the foramen ovale (*f.ov.*). Anteriorly, below the pterygoid flange, the bone is tunnelled by a canal which represents the united sphenoidal fissure and foramen rotundum (III.-VI.). A couple of venous foramina (*v.f.*) appear externally on the alisphenoid. These were traversed by the vessels which united inside the skull to form the large vein already mentioned as running into the transverse sinus. On its upper surface the alisphenoid is very deeply grooved to shelter the cranial nerves lying on it. These grooves are better seen from the cast. They will be mentioned later. In section, the basisphenoid is seen to

be a thick bone, and it is scarcely thinned by the shallow pituitary fossa.

On the dorsal surface of the skull the *frontals* form a flat arrowhead-shaped area between the post-orbital ridges. Laterally they are concave. Below, they unite by suture with the ali- and orbito-sphenoids, and they extend well down on the skull since the palatines cannot be traced below them. Within the skull they form the division between the olfactory and cerebral cavities. In front and above they are hollowed out by the frontal air-sinuses.

The *orbitosphenoid* is quite small. Its suture with the ali-sphenoid is not plain, but it appears to completely surround the optic foramen. It is indistinguishably fused with the *presphenoid*, which is a very long and thin bone with a marked median palatal ridge. It is very thick, and its upper surface, as seen in section, is shaped like the roof of a house, that is, its surface is very high in its middle length and slopes down both forwards and backwards (text-fig. 154, p. 882). The posterior slope shares in the tunnel for the optic nerve, while the anterior one is excavated by a rounded, undercut hollow which gives a firm support to the cribriform plate (*cr.p.*). This last bone is a solid mass of perforated tissue and presents no special points of interest.

Comparison of the specimen with the figures given by Cuvier [1] and Blainville [2], as well as with the casts available at the British Museum, leaves little doubt but that the skull has been correctly identified. In Cuvier's figures the general form of the skull with the postorbital constriction, the form of the condyles, the immense paroccipital processes, the peculiar formation of the meatus, the post-glenoid process, its foramen, and a host of other details are identical. Fig. 1, pl. xlv. of Cuvier's 1822 edition shows the upper surface of the base of the skull of an *Anoplotherium* determined from the teeth, and the arrangement of the foramina, of the grooves for the nerves, and of the transverse sinus agree precisely with this specimen. The agreement with Blainville's figures is no less conclusive, and though the crests on the skull are considerably stronger than those in any specimen figured by these writers, they are of the same form, and their degree of development can hardly be of greater than specific value when other features agree so markedly.

Support for the identification also comes from the brain-cast, for it agrees essentially with the natural one figured by Blainville on plate ii., but not with the one given by Cuvier (plate lv., 1822 edit.), which is incorrectly identified as an *Anoplothere*.

#### *Brain-cast.*

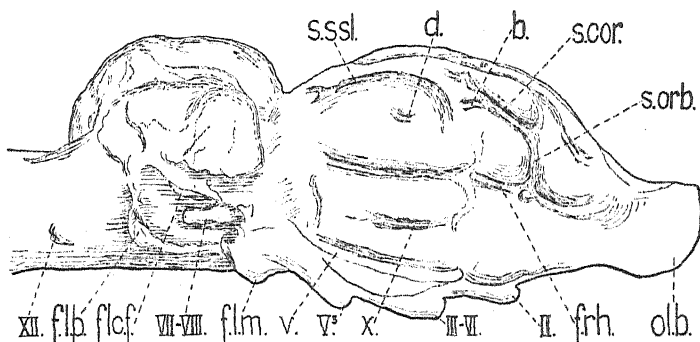
The narrow, elongate form of the skull is naturally also a feature of the brain. Its total length from the front of the olfactory bulbs to the caudal end of the cerebellum is a fraction under 10 cms. Of this total, the cerebrum accounts for 5.6 cms.,

the cerebellum for 3.35 cms., and the olfactory bulbs for the remaining 1 cm. The cranial capacity, as measured with sand from the cast, is 86 cc.

The parts of the cerebral hemispheres chiefly concerned with the sense of smell, are, as usual in early Tertiary mammals, highly developed. This is seen in the large size of the olfactory bulbs and of the rest of the "smell-brain," and in the small size of the neopallium. The greatest width of the cerebrum, which is near its caudal extremity, is 45 mm.

The cerebellum is separated from the hemispheres, but there is no evidence that the corpora quadrigemina were exposed. Its width cannot be measured accurately, owing to the casts of the cavities for the transverse sinuses being continuous with its mass on each side. Estimating the extent of these sinuses, its transverse is not much more than its antero-posterior diameter—that is, about 37 mm.

Text-fig. 155.



Lateral view of brain-cast of *Anoplotherium*.

*fl.c.*, flocular lobe; *fl.m.*, cast of foramen lacerum medium; *fl.p.*, cast of foramen lacerum posterius; *fr.h.*, rhinal fissure; *ol.b.*, olfactory bulb; *s.cor.*, coronal sulcus; *s.orb.*, orbital sulcus; *s.ssl.*, suprasylvian sulcus; *v.*, vessel; *II.*, *III-VI.*, *V.*, *VII-VIII.*, casts of foramina of cranial nerves.

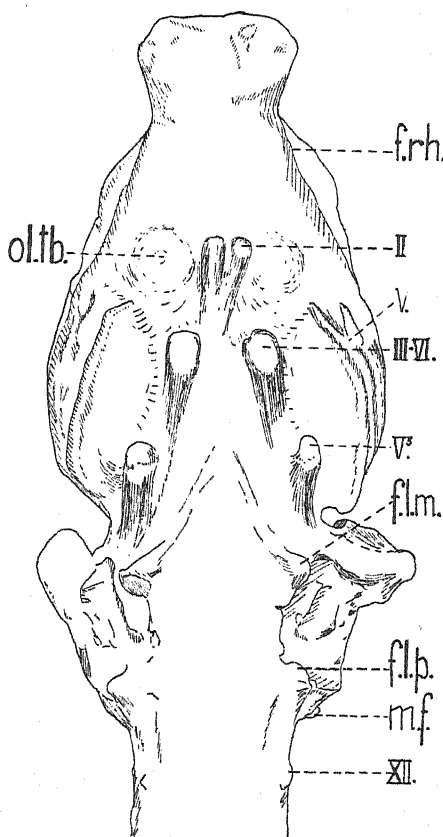
Looked at in side view (text-fig. 155), the cerebellum stands as high above the axis of the brain as does the cerebrum. This is no doubt a primitive feature, for in recent Ungulates the hemispheres are distinctly more elevated than the cerebellum. The Middle Eocene *Palaosyops* agrees with *Anoplotherium* in this particular [3].

On the base of the brain the courses of the cranial nerves and the casts of the lacerate foramina are conspicuous, while below the flocular lobe on each side the periotic has left a ragged scar.

The brain, in general form, arrangement of parts, and furrows, is remarkably similar to that of *Orycteropus*. This is seen in side view, and especially from below. If the figure of the ventral

surface of the brain of the Aard-Vark given by Elliot Smith [4] be compared with text-fig. 156, the similarity will be seen to be very striking. The detailed resemblances will be noticed below, and they undoubtedly help to strengthen the evidence in favour of a primitive Ungulate origin for the Tubulidentata—a view held by Elliot Smith, Max Weber, and Lönnberg.

Text-fig. 156.

Ventral view of brain-cast of *Anoplotherium*.

Lettering as in text-fig. 155, with addition of *m.f.*, mastoid foramen;  
*ol.tb.*, olfactory tubercle.

#### *Ventral Surface of Cerebrum.*

The whole of this region is well developed. This can be clearly seen from text-fig. 156, for, seen from below, the pyriform lobes almost completely conceal the neopallium—a part of which is

visible only to the outside of the anterior parts of the pyriform lobes. *Anoplotherium*, then, was far more highly macrosomatic than any living Ungulate, and not much less so than the burrowing Aard-Vark.

The *olfactory bulbs* at their widest part are together 21 mm. across. The olfactory peduncles are distinct thick stalks, swelling out behind into the anterior ends of the pyriform lobes.

The *olfactory tubercles* are well shown as smooth circular elevations placed rather further back than in *Orycteropus*, and sufficiently prominent to be noticeable in a side view of the cast.

Between these tubercles the cast shows the course of the *optic nerves*. These tunnelled the base of the skull very near the middle line. The position of the chiasma is indicated by the sinking of these tubular casts on to the general level of the brain-surface. Diverging outwards from the chiasma, the valliculae Sylvii are distinct, marking off the globular posterior parts of the pyriform lobes. Running back along the lower surface of each of these lobes is the cast of the vein described as running on the side of the cranium. This vessel does not seem to be cerebral, but rather to collect blood from the diploë of the bones. The only other feature on the pyriform lobe worthy of note is a short straight fissure running along it, above the vessel just mentioned, and below and parallel to the rhinal fissure. A similar fissure occurs in the pig and the tapir. In text-fig. 155 (p. 886) it has been marked with the letter "x."

#### *Lateral Surface of Cerebrum.*

The *olfactory bulbs* having been described from below need no further mention.

The *neopallium* is clearly marked off from the rest of the hemispheres by the great horizontal *rhinal fissure*. In text-fig. 155 there is a break in this fissure at about one-third of its total length from the front. This break does not occur on the other side, and seems to be due to damage of the skull-wall. In side view the rhinal fissure is seen to divide the hemisphere horizontally into two equal parts, and the primitive character of the brain is emphasized by the relatively small size of the upper part (*neopallium*) in comparison with the rest of the cerebrum. Its great development in the higher mammals, which led to the degeneration of the "smell-brain" and to its enwrapping by the *neopallium*, has scarcely begun.

About 17 mm. from the anterior end of the hemisphere, there is a vertical sulcus running into the rhinal fissure below, and connected, on the right side only, by a shallow furrow with the lateral sulcus. This sulcus can be no other than the *orbital* \*. Its

\* I am using the same terms as were employed in the descriptions of the brain of *Orycteropus* [4], to which I have referred, although Dr. Elliot Smith tells me the whole question of nomenclature of cerebral sulci urgently needs revising in the light of recent research on anatomical localization of the cerebral cortex.



position, relation to the rhinal fissure, and its possible connection on the right side to the lateral sulcus are exactly like the conditions in the brain of *Orycteropus*.

Behind the orbital, the side of the hemisphere is marked by a clearly defined sulcus, rather under 2 cms. in length, and running obliquely from behind forwards and downwards to join the orbital. This sulcus is nearly certainly the *coronal*. Its relations on the two sides are similar, but while on the left it is simple, on the right it forks slightly at its superior or dorsal end, and in its middle length it is connected with a very short horizontal sulcus (*b*), the identity of which is not clear.

There is no trace of a pseudosylvian sulcus on either side of the brain.

Dorso-laterally the neopallium is marked by a sulcus which, starting at the back of the hemisphere, runs straight forward, parallel to the middle line, for about 2 cms., and then, curving down towards the rhinal fissure, ends on the right side, about 7 mm. from that fissure, but on the left actually joins it, or very nearly so. This must be the *suprasylvian sulcus*. Though small and not so strongly arcuate as in the higher Ungulates, it is of the typical Ungulate form in the strength of its posterior branch. Near its caudal end the posterior limb of the suprasylvian is joined by a very short sulcus (*c*), which lies external to it. This sulcus, though minute, is constant on both sides.

Midway between the suprasylvian sulcus and the rhinal fissure, and within the curve of the former, there is a short deep horizontal sulcus about 5 mm. long on the right side, and about twice that length on the left. This sulcus is exactly analogous in position to a similar short one in *Orycteropus*. For purposes of reference it will be spoken of as sulcus "*d*."

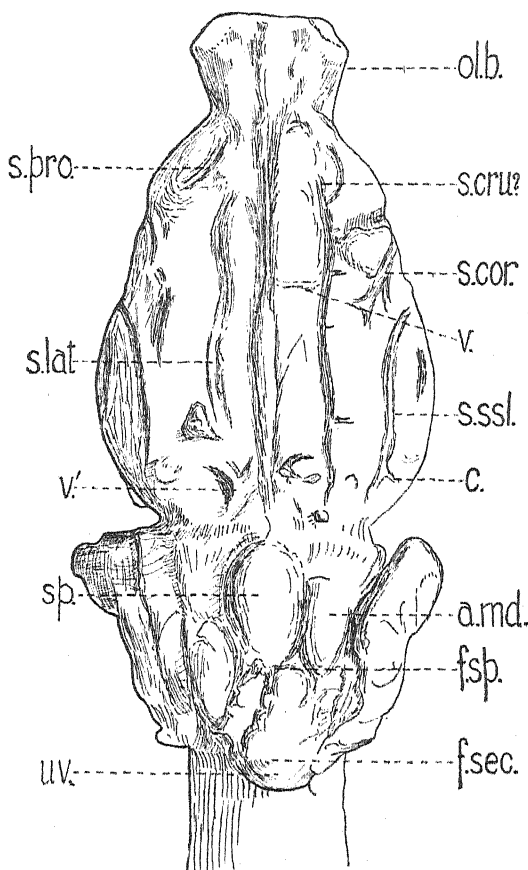
On the *dorsal surface* of the neopallium (text-fig. 157, p. 890), running in general parallel to, and on an average about 7 mm. from, the middle line, is a deep sulcus, which extends from very near the olfactory peduncle to the posterior surface of the hemisphere. This long furrow bears several branches and is really compound. On the left side of the brain, the most anterior part of it, about 1 cm. long, lies further from the middle line than the rest of the furrow, and was probably not directly continuous with it, though in the cast there is a connection by means of a shallow depression. This short sulcus must be the *prorean*. On the right side it is directly continuous with the rest of the sulcus, which is clearly the *lateral*. The relation between the prorean and lateral sulci is exactly as in *Orycteropus*.

The large lateral sulcus, though roughly parallel to the middle line, is by no means straight, and pursues a sinuous course along the hemisphere. On the right side it has two very short branches going outwards from it, at distances respectively of 1.5 and 3.3 cms. from its caudal extremity.

At the junction of the prorean and lateral sulci on each side there is another sulcus, a few millimetres in length and running

straight forward. What exactly this represents is not clear. It may possibly be a rudiment of the *crucial*.

Text-fig. 157.



Dorsal view of brain-cast of *Anoplotherium*.

Lettering as in text-fig. 155, with addition of *a.md.*, area medullaris; *f.sp.*, fissura suprapyramis; *s.cru.?*, crucial sulcus (?); *s.lat.*, lateral sulcus; *sp.*, suprapyramis; *s.pro.*, prorean sulcus; *uv.*, uvula; *v.*, *v'*, vessels.

At this point a couple of blood-vessels, marked on the dorsal surface of the cast, may be mentioned. On the right side, a small transverse ridge in the middle of the hemisphere and near the middle line may represent the course of one of the meningeal vessels or of a branch of the internal carotid artery. Branches of this latter artery probably account for some of the obscurity of

the brain-surface behind the orbital fissure, where the cast shows the marks of the fronto-parietal suture.

Posteriorly, between the lateral sulcus and the middle line, traces of a spacious paired vessel (*v'*) are seen. This is formed by two branches, one of which strikes out from the median line, while the other comes inwards and backwards from the surface of the brain. The main trunk, from its direction, seems to have gone round the tentorium and to have joined the transverse sinus. It was probably a vein collecting blood from the superior surface of the hemisphere.

### *Cerebellum.*

The general proportions of this part of the brain have already been given. The cast does not, of course, show the minute folding of the cortex characteristic of a fresh specimen, but the main areas and the chief fissures are distinctly marked.

The most striking feature of this organ in *Anoplotherium* lies in the small size of the lateral lobes. This is probably a primitive feature, since, in a comparative series, evolution in the cerebellum is chiefly marked by the development of these parts [4].

The three fundamental divisions of the cerebellum are indicated by transverse fissures marked on the vermis.

The *fissura prima* is not very clearly shown, but there is a suggestion of a groove in the place where it nearly certainly must have been situated, on the dorsal part of the anterior face of the vermis.

The *fissura secunda* is clearly shown on the posterior surface of the vermis, marking off from the rest of the cerebellum a smooth hemispherical area, which faces posteriorly and is undoubtedly the *uvula*—the anterior division of the lobus posticus.

The whole of the dorsal part of the vermis belongs to the *lobus medius*. It is divided into two almost exactly equal parts by a transverse fissure, which can be nothing but the *fissura suprapyraxis*. The vermis of the median lobe shows a twist such as is seen in a great number of mammals of different groups, and which gives a marked asymmetry to the organ.

To the sides of the suprapyraxis—that part of the vermis of the median lobe anterior to the suprapyraxial fissure—lie triangular depressed areas indicating the exposure of white matter such as is found in many small mammals including most Marsupials, Rodents, Bats, etc. [5]. For this region Elliot Smith has suggested the term "*area medullaris*."

To the sides of the pyramis lie the indefinite masses of the *lateral lobes*, the small size of which has been commented on above. Their irregular form adds greatly to the asymmetry of the whole organ.

To the outside of the lateral lobes lie the probably relatively large *floccular lobes*. These can be traced as being connected behind, in the usual manner, to the pyramis. Below, they rest on the periotics and fill in the floccular fossæ. Their exact extent

cannot be determined, owing to the continuity of their casts with those of the transverse sinuses.

Such a primitive form of cerebellum *in an organ of this size* is unknown, except in Marsupialia (*Macropus* and *Thylacinus*) [6].

### *Brain-stem.*

In cranial casts this region is never represented with any accuracy, owing to the fact that the nerves and vascular spaces, which lie below the brain, obscure the outlines of the latter.

Conspicuously shown (text-fig. 156, p. 887) to the outside of the pituitary region are the courses of the nerves escaping by the sphenoidal fissure (which, as mentioned above, is confluent with the foramen rotundum) and by the foramen ovale.

The course of the trigeminal nerve can be followed from the outside of the region of the Pons Varolii, along a groove in the alisphenoid to the foramen ovale, through which it gave off its mandibular branch, and then, still lying in a groove on the bone, the second and first branches ran forward to pierce the skull with the third, fourth, and sixth nerves through the sphenoidal fissure. Occupying the centre of the figure formed by these two pairs of foramina casts, the pituitary body is represented, but the extreme shallowness of its fossa makes it very inconspicuous. The posterior clinoid processes leave a scarcely noticeable impression on the plaster.

As to the divisions of the rest of the brain-stem nothing can be distinguished. It only remains to describe the casts of the petiotic region, of the foramina for the veins of the sinus, and of the last cranial nerves.

The petiotic bone has left an irregular crater-like scar on the side of the cast (text-fig. 155, p. 886). This hollow is walled by various nodose elevations, which are chiefly casts of parts of the transverse sinus. In the centre of the "crater" a tiny ridge represents the passage through the internal auditory meatus and the Aqueductus Fallopii of the VIIIth and VIIth nerves. The upper boundary of the crater is formed by the cast of the floccular fossa. In front and below is the cast of the foramen lacerum medium, from which a slight ridge runs forward on the base of the brain to meet its fellow of the other side below the pituitary fossa. This ridge may have some connection with the course of the internal carotid. Below and at the back of the petiotic depression, an elevation represents the foramen lacerum posterius. At the back of the floccular lobe of the cerebellum, a tiny knob marks the position of the mastoid foramen (text-fig. 156, *m.f.*).

On the side of the medulla oblongata, in line with the jugular foramen, the exit of the XIIth nerve is represented by a tubercle which is the last feature to be seen on the cast.

At this point a summary of the resemblances between the brains of *Orycteropus* and *Anoplotherium* may not be out of place. The Aard-Vark's brain has been described as differing from a primitive Ungulate type only in a higher development of the olfactory parts. The only other important contrast with the

Ungulate brain lies in the insignificance of the suprasylvian sulcus compared with the lateral, which is the reverse of the usual condition found in that group [4].

The brain of *Anoplotherium* has the general proportions of that of *Orycteropus*, and the "smell-brain" is nearly as well developed. The horizontal continuous rhinal fissure in the brain of the first agrees with the usual condition in the second. The relations of the orbital, prorean, and lateral sulci agree in both. The suprasylvian sulcus of the Anoplothere is much more developed than in *Orycteropus*, but its size in relation to the lateral sulcus is intermediate between the usual Ungulate condition and the state of affairs in *Orycteropus*. The brain of the Aard-Vark has long been known to approach the Ungulate type, and in *Anoplotherium* we have an Ungulate which somewhat approaches the Tubulidentate type.

On the ventral surface, the differences between the two brains are practically all accounted for by the different degrees of macromatism. In the cerebella there are no striking similarities, but there is nothing to contradict a relationship.

If cerebral anatomy be of any systematic value, the view that *Anoplotherium* and *Orycteropus* arose from a common, though necessarily remote, ancestry can hardly be doubted.

In conclusion, I must emphasize my indebtedness to Prof. Elliot Smith, whose notes on the brain-cast I have freely used, and who has given me a great deal of help in many other ways. My thanks are also due to Dr. Andrews and Mr. D. M. S. Watson for kindnesses received at the British Museum.

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51. The Fossil Crinoids referred to *Hypocrinus* Beyrich.

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(Plate XC. and Text-figures 158-160.)

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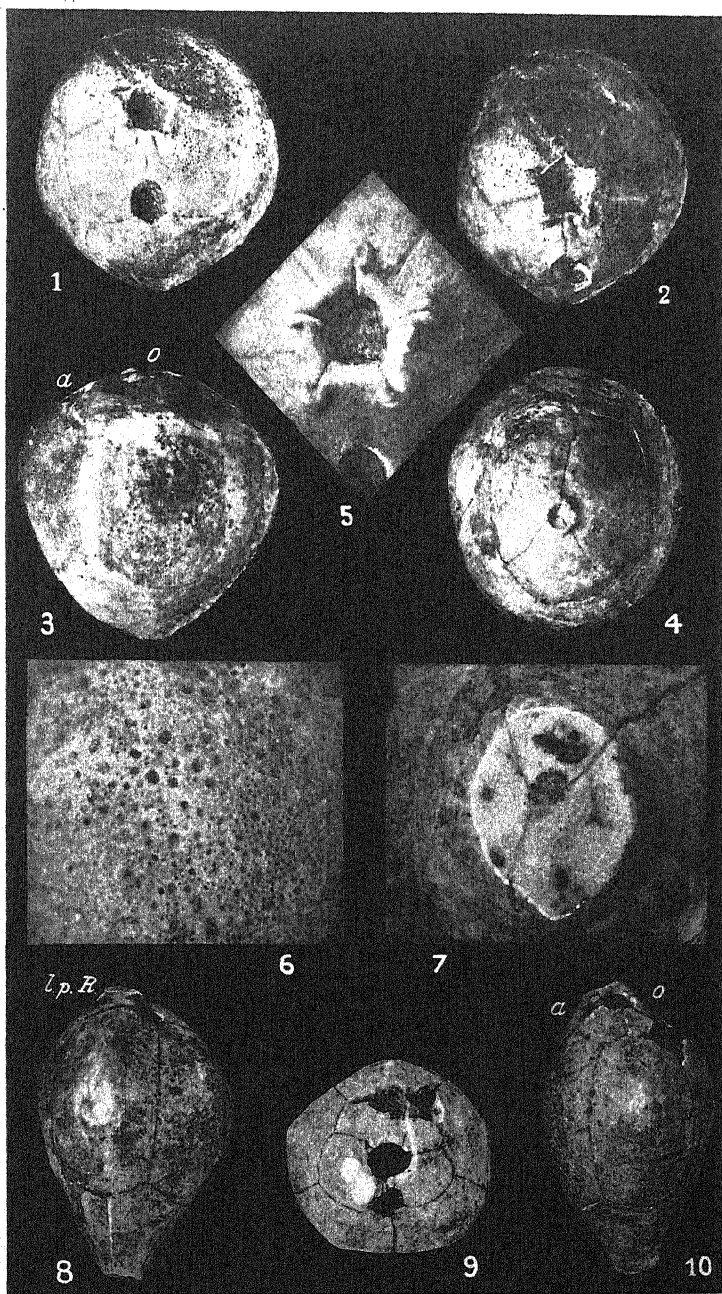
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## PREFACE.

Early in 1908 a crinoid cup from the Carboniferous rocks of Yorkshire, elsewhere described as *Cydonocrinus parvulus*†, was submitted to me by Mr. D. M. S. Watson. Some curious features in it suggested a comparison with *Hypocrinus*, which had occupied my pen at intervals during the previous twenty years, but of which I had not seen actual specimens. Without delay all the known fossils that had been referred to the genus were borrowed for study. This proved a lengthy business, involving patient preparation and microscopic examination. By the end of 1910, however, their description was drawn up and a series of illustrations prepared, when another specimen was reported as obtained from Timor by the Elbert-Sunda Expedition. Correspondence ensued with Dr. J. Elbert and Dr. J. Wanner, but the latter

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† F. A. Bather, 1913, "British Fossil Crinoids, IX.," Ann. Mag. Nat. Hist. ser. 8, vol. xii. pp. 388-394.



H. G. Herring. Phot.

London Stereoscopic Co. Imp.

1-6. HYPOCRINUS SCHNEIDERI. 7-10. "H." PIRIFORMIS.





was away in Timor, and access to the specimen proved for the time impossible.

My paper, therefore, was laid aside and other work taken up. Until the publication of that work in July of this year (1913) I could not return to *Hypocrinus*; then, just as I was about to do so, I was informed that Professor Wanner wanted to see the specimens that were in my hands, because he intended to redescribe the species in his account of the Permian Echinoderms collected by himself in Timor. Naturally I resumed at once the communications with Professor Wanner, but, friendly though our exchange of views and of information has been, I regret that it has proved impossible for us to come to any arrangement more convenient to our colleagues and to future workers than this: that I shall publish my discussion of the original specimens, and that the description of the new material shall be left to Dr. Wanner.

This paper, then, is admittedly a fragment. References to one or two recent papers have been introduced, and my observations have in places been checked or corroborated by the information courteously sent me for this purpose by Prof. Wanner. But in its main lines the paper stands as it was written more than three years ago. It will, I hope, be accepted as Prolegomena to Prof. Wanner's memoir, relieving him of much needful drudgery, but not forestalling his more important results.

#### PREVIOUS HISTORY.

The genus was founded by Beyrich (1862, Zeitschr. deutsch. geol. Gesell. Bd. xiv. p. 537) to receive the single species *Hypocrinus schneideri*, based on a unique cup from the bed of a brook, Kali Mati or Ajer Mati (the dead water), about half a kilometre south of Kupang in Southern Timor. Beyrich (1865, Phys. Abhandl. Akad. Wiss. Berlin, Jahrg. 1864, p. 83), when publishing a fuller description, was doubtful whether his new genus was a Crinoid or a Cystid, being inclined to the latter view by the curious infra-radial position of the anal opening.

The first author to notice the new genus was Quenstedt, who, in his 'Handbuch der Petrefaktenkunde' (ed. 2, 1867, p. 751), definitely referred it to the Cystidea, placing it with *Echinoencrinites*, but separating it from *Cryptocrinus*. In 'Petrefaktenkunde Deutschlands' (1876, Bd. iv. p. 687), Quenstedt put *Hypocrinus*, together with *Cryptocrinus*, near *Echinoencrinites* and its allies, although he considered that the probable presence of five large arms brought it near to the true Crinoidea. In the Atlas to that work, pl. 113, fig. 94, Quenstedt gave a view of the posterior side, and another of the base. These views show the relation of the basals to the posterior side, and thus indicate the position of the small basal, a piece of information not given by Beyrich. Unfortunately, Quenstedt's interpretation of the base proves incorrect. In the third edition of the 'Handbuch

der Petrefaktenkunde' (1885, p. 967) *Hypocrinus* was still placed with *Echinoecrinites* and its allies.

Zittel (1875, 'Handbuch der Palaeozoologie,' Bd. i. p. 413), who established the Cystidean group Aporitidae on the lines indicated by Müller (1854), placed *Hypocrinus* therein next to *Cryptocrinus*. R. Hoernes (1884, *Élém. d. Pal.* pp. 123, 124), remarking that both genera possessed pores, especially *Hypocrinus*, transferred them to the Caryocrinidae. *Hypocrinus* was also associated with *Cryptocrinus* by M. Neumayr (1889, 'Die Stämme des Thierreiches,' p. 403), who, however, made no particular remarks on the genus.

*Hypocrinus* was not mentioned by Wachsmuth and Springer in their 'Revision of the Palaeocrinoidea,' although the name appears within round brackets in their privately issued index.

Before 1890 no one had placed the genus anywhere except with the Cystidea; in that year, however, in the second of my papers on "British Fossil Crinoids" (*Ann. Mag. Nat. Hist.* ser. 6, vol. v. p. 324), I associated it with *Achradocrinus*, stating that it appeared to differ from that genus only in having three infrabasals instead of five. In the concluding part of the same paper (*tom. cit.* p. 385) *Achradocrinus* and *Hypocrinus* formed Series 3, Achradocrinites, in the family Cyathocrinidae, Series 2 being Codiocrinites, containing *Codiocrinus* and *Lecythiocrinus*.

The view that *Hypocrinus* was a crinoid was accepted by P. Herbert Carpenter (1891, "On certain Points in the Morphology of the Cystidea," *Journ. Linn. Soc., Zool.* vol. xxiv. pp. 14-16). "*Hypocrinus*," he said, "is certainly a very singular form and one would like to know more about it." Carpenter considered it to be allied to *Lecythiocrinus* White, of the Coal Measures of Central North America, but also mentioned its affinity to *Codiocrinus*.

Our knowledge of the genus was increased through two cups collected by Dr. A. Wichmann in 1888-9 at the same locality of Ajer Mati, and described by Professor A. Rothpletz (1892, 'Palaeontographica,' Bd. xxxix. p. 74) under the names *Hypocrinus milleri* Beyr. (a *lapsus calami*, as Prof. Rothpletz tells me, for *H. schneideri*) and *Hypocrinus* (?) *pyriformis* (melius *piriformis*), n. sp. Since Dr. Rothpletz stated that Crinoidea were represented in the Wichmann Collection by columnars alone, and since between their description and that of *Hypocrinus* he placed the account of an echinoid radiole, he must be supposed to have regarded *Hypocrinus* as a Cystid.

Whether the views of Herbert Carpenter and myself were unknown to foreign writers or whether we were merely thought unworthy of attention, subsequent authorities continued to refer *Hypocrinus* to the Cystidea, associating it as before with *Cryptocrinus*. Among text-books one notes Félix Bernard (1893, *Élém. de Paléont.* p. 159), Von Zittel (1895, 'Grundzüge der Paläontologie,' p. 155), and Koken (1896, 'Die Leitfossilien,' p. 290). In 1895, Dr. O. Jaekel was describing from the Devonian

of Germany several crinoids which I regard as close allies of *Hypocrinus*, but he did not mention that genus for comparison. Haeckel (1896, "Die Amphorideen und Cystoideen," Festschr. für Gegenbaur, Bd. i. p. 147) dealt with the genus between *Cryptocrinus* and *Lichenocystis*, but concluded his description by saying: "wegen ihrer sonstigen nahen Beziehungen zu einfachsten Crinoideen könnte man sie auch für reduzierte oder verkümmerte Formen dieser Klasse ansehen." This statement, while perfectly true as regards *Hypocrinus*, is not equally applicable to *Cryptocrinus*.

Undismayed by this weight of authority, in a "Phylogenetic Classification of the Pelmatozoa" (1899, Rep. Brit. Assoc. 1898, p. 923) I placed *Gasterocoma*, *Scoliocrinus*, *Achradoocrinus*, and *Hypocrinus* in the family Gasterocomidae, which came in the suborder Cyathocrinoidea, among the Dicyclica Inadunata. This family was maintained, with the addition of *Nanocrinus*, on pp. 177, 178 of my contribution to Lankester's 'Treatise on Zoology' (Part III. Echinoderma, 1900).

In the second edition of the 'Grundzüge der Paläontologie' (1903, p. 141) Von Zittel included in the family Gasterocomidae the same genera as I had placed in it. His example was followed by Počta (1904, 'Rukověť Palaeozoologie,' I.), who, however, quoted *Hypocrinus* as "permokarbon ruský."

Delage and Hérourard (1904, 'Traité de Zoologie concrète,' Tome iii. pp. 379, 380) reduced my suborder Cyathocrinoidea to the rank of a family Cyathocrinusinae, but retained *Hypocrinus* and the other genera in the same relative position.

The latest writer to maintain *Hypocrinus* in the Cystids under a family Cryptocrinidae appears to be Dr. G. H. Girty (1908, "Guadalupean Fauna," Professional Paper 58, U.S. Geol. Surv. p. 108). This he has done in connection with the description of *Coenocystis richardsoni*, an alleged new genus and species of this Family, from the Delaware Mountain Formation of uppermost Carboniferous age in Texas. Whatever *Coenocystis* may be, I find no reason for supposing it to be a Cystid. But even if it were, this would not affect the position of *Hypocrinus*, which, as Dr. Girty says, is evidently distinct.

The preceding account shows that the position now occupied by *Hypocrinus* in our leading text-books depends chiefly upon the opinions expressed by Herbert Carpenter and myself. It is, therefore, advisable to point out that, when we wrote, neither of us had examined any specimens of *Hypocrinus*. For us it remained, as Carpenter expressed it, a very singular form which one would like to know more about. At last, the great courtesy and kindness of Professors Dr. W. Branca of the Museum für Naturkunde, Berlin, and Dr. C. E. A. Wichmann of Utrecht University, have enabled me to study all the described specimens of this genus. The following pages contain redescriptions of that material and fresh diagnoses.

## CRINOIDEA DICYCLICA INADUNATA.

## Suborder CYATHOCRINOIDEA.

Dr. Frank Springer, in his paper on "Some new American Fossil Crinoids" (July 1911, Mem. Mus. Comp. Zool. Harvard, vol. xxv. no. 3), has published a very interesting discussion of my Suborders Cyathocrinoidea and Dendrocrinoidea. While differing as to the delimitation of these divisions and the principles upon which they are based, he readily agrees in recognizing their existence. He prefers to regard them only as large Families, to which he applies the names Cyathocrinidae and Poteriocrinidae, but admits that this is "a matter of detail, depending upon the general plan of treatment." It was necessary for me to treat them either as Suborders or Superfamilies, because I split them up into Families, several of which are again divided into Subfamilies. I am, therefore, emboldened to retain for the present the Suborder Cyathocrinoidea.

## Family Gasterocomidae.

Cyathocrinoidea with anal opening in the side of the dorsal cup, below the level of the arm-bases. Radial facets of horse-shoe shape, with distinct axial canal. Infrabasals small, often fused into three plates or one. Orals, so far as known, for the most part concealed by the cover-plates of the subvective system; posterior oral a large madreporite. Stem frequently with peripheral canals.

Dr. Springer, in the above-quoted memoir (July 1911, p. 122), has given a full account of the Gasterocomidae, although he has not provided any fresh diagnosis. The characters which he mentions as distinctive are included in the above diagnosis, which differs only verbally from that published by me in Lankester's 'Treatise on Zoology' (Part iii. 1900, p. 177). Dr. Springer further agrees with Jaekel and with me in referring to the Family the genera *Gasterocoma*, *Nanocrinus*, *Scoliocrinus*, and *Achradoocrinus*. To these he adds a new genus, *Schultzicrinus*, found in the Onondaga Group of the Middle Devonian in Livingston County, New York. This genus has the infrabasals coalesced and five simple uniserial arms. Further, Dr. Springer adds *Arachnoocrinus* Meek and Worthen, of which he has made a complete study, showing that our previous views as to the structure, and therefore as to its systematic position, were erroneous. This genus differs from *Schultzicrinus* mainly in having dichotomous arms. I am, of course, prepared to accept its reference to the Gasterocomidae.

Apparently, Dr. Springer would also place in the Gasterocomidae the genus *Myrtillocrinus* Sandberger, of which he considers *Tripleuroocrinus* E. Wood to be a synonym. In this he follows Wachsmuth and Springer ('Revision of the Palaeocrinoidea,' 1885), as well as some other writers therein quoted. It may, however,

be pointed out that the genotype, *Myrtillocrinus elongatus* Sandberger, is not very well known, and that Dr. Springer here bases most of his argument on *M. americanus* Hall, which possibly has not the same structure. If, however, we accept the generic identity of the two species, then it follows that *Myrtillocrinus* is devoid of the most characteristic feature of the Gasterocomidæ, namely, the passage of the anus through the dorsal cup. It seems to me, therefore, as it did to Prof. O. Jaekel (1895, Pal. Abhandl. Bd. vii. p. 75), that the Family Gasterocomidæ is far more homogeneous if *Myrtillocrinus* be removed from it. Whether I was right in placing it with the Cupressocrinidæ is another matter, not worth discussion until Sandberger's type-specimen has been restudied.

Dr. Springer, on p. 138, somewhat casually mentions *Hypocrinus*, but leaves its systematic position uncertain. On the grounds of its structure *Hypocrinus* is naturally referred to this Family, and there does not appear to be any objection to that course, except the fact that all the other genera of the Family are restricted to the Middle Devonian, whereas *Hypocrinus* is not known below the top of the Carboniferous. This difficulty is scarcely lessened if the species *Lecythiocrinus adamsi* Worthen be proved to belong to *Hypocrinus*, since that species is similarly removed by a large interval of time from the rest of the Gasterocomidæ, being found about the horizon of Coal No. 8 of the Lower Coal Measures in Peoria County, Illinois.

According to Worthen's description and figure of *Lecythiocrinus adamsi* (1882, Bull. Illinois State Mus. Nat. Hist. no. 1, p. 37; and 1883, Geol. Surv. Illinois, vol. vii. p. 317), that species has five infrabasals, and therefore could not be referred to *Hypocrinus*. This fact, however, would not prevent its being placed with the Gasterocomidæ, since *Achradocrinus* also has five infrabasals. The reason for placing this species with the Gasterocomidæ is that "Just above the summit of one of the subradials [basals], and in the lateral angles of two of the radial plates, there appears to have been a circular opening, rather larger than the arm-facets, which is now filled with stony matter" (Worthen). This no doubt is an anal opening, as suggested by Worthen himself.

Although, for reasons of structure, *Lecythiocrinus adamsi* and the species hitherto referred to *Hypocrinus* are naturally placed in the Gasterocomidæ, it should not be forgotten that this peculiar disposition of the anus may have arisen independently in the late Carboniferous Cyathocrinoidea. In that case, the forms in question, wherever they might be referred, would not belong to the Gasterocomidæ.

#### HYPOCRINUS.

1862. *Hypocrinus* H. E. Beyrich, Zeitschr. deutsch. geol. Gesell. Bd. xiv. p. 537.

For other references, see "Previous History."

**Diagnosis.**—A Gasterocomid with anal opening at the summit

of the posterior basal, and at the lower angles of the right and left posterior radials, which meet above. Two pairs of infrabasals fused; the remaining small infrabasal being the anterior. Radial facets small. (Arms unknown.) Stem-facet from .13 to .2 diameter of cup. (Stem unknown.)

The diagnosis is based on the characters of the genotype, since *H. piriformis* must be removed from the genus. The somewhat hexagonal shape of the anal opening suggests that it was closed by six valvular plates.

**Genotype.**—*H. schneideri*.

**Distribution.**—This species, as well as "*Hypocrinus*" *piriformis*, has been found only in Timor, in beds which are either Permian or Carboniferous. Recent workers have regarded them as Permian, but the Echinoderms at present described would rather favour a Carboniferous age. I have already discussed this in my account of *Schizoblastus* from Timor (1908, N. Jahrb. f. Mineral., Beil.-Bd. xxv. p. 318). The affinities of *Hypocrinus* also, as shown above, are closer to the Upper Carboniferous "*Lezythiocrinus*" *adamasi*, if not to the Devonian Gasterocomidæ, than they are to anything as yet known from undoubted Permian rocks. It is of no avail to discuss the question further in this place, for the abundant materials collected by Dr. J. Wanner and others will probably settle it when they have been described. I would only suggest that the possibility of some of the fossils being derived from older beds should be borne in mind. Some of the few Echinoderms that I have studied had certainly been much worn before they were included in their present matrix.

**HYPOCRINUS SCHNEIDERI.** (Pl. XC. figs. 1-6; text-figs. 158, 159.)

1862. *Hypocrinus schneideri* H. E. Beyrich.

1865. *Hypocrinus schneideri* Beyr.; H. E. Beyrich.

1892. *Hypocrinus milleri* [err. pro *schneideri*] A. Rothpletz.

For references, see "Previous History."

**Diagnosis.**—This being the only undoubted species of *Hypocrinus* known to me, no specific diagnosis can be given.

**Holotype.**—The original of Beyrich's figures (1865) preserved in Museum für Naturkunde, Berlin (our Pl. XC. figs. 1-4).

The only other specimen described is that of Rothpletz (1892).

**Locality.**—Both specimens come from Ajer Mati, S. of Kupang, Southern Timor.

**Horizon.**—Permian? (*vide supra*).

**Description of Holotype.**—A dorsal cup, with no trace of stem, anal plates, brachials, or tegmen. Surface of stereom stained pinkish. Infilling matrix, soft micro-crystalline calcite with small dark specks.

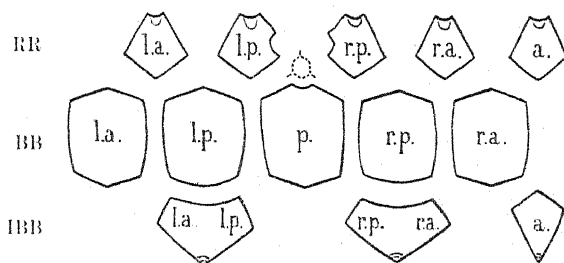
General shape squat, pyriform. Cross-section subpentagonal, owing to projection of umbones of basals, which is especially marked in the posterior basal. Height 20.8 mm.; greatest sagittal diameter 20.8 mm., greatest transverse diameter 19.9 mm., these being at about 14.5 mm. from basal plane.

Stem-facet (Pl. XC. fig. 4) circular, markedly concave, bounded by a slight rounded rim; external diameter 2·7 mm.; internal diameter 1·75 mm. Lumen circular, about ·3 mm. diameter. There are exceedingly faint traces of about 15 or 16 radiating grooves.

Infrabasals (Pl. XC. fig. 4) closely united. The posterior suture is most distinct, chiefly because a crack is partially co-incident with it. When the specimen reached me the right anterior suture could scarcely be detected, only being indicated by a faint band of lighter colour. Various processes of preparation have now rendered it perfectly visible. The left anterior suture at first seemed conspicuous, but the appearance was due to a rather irregular crack continuous with that noticed along the posterior suture. The left anterior suture itself could not be traced with certainty; it now appears to be only in part co-incident with the crack. In the concavity of the base, after careful preparation, there are dimly seen two dark streaks running from the lumen in the direction of the posterior and right anterior sutures respectively. There appears to be a third such streak a little on the anterior side of the above-mentioned crack; and this streak probably indicates the position of the left anterior suture.

It follows from the preceding account that Beyrich's description and figures of the base, as composed of two large plates and one small plate, though unsupported by valid evidence, were in the main correct. His figures are little more than inexact diagrams, and neither they nor the text indicate the position of the small infrabasal; it is anterior (text-fig. 158).

Text-fig. 158.

*Hypocrinus schneideri*.

Analysis of the cup of the holotype.

The periproctal outline is dotted in. Nat. size.

Heights of IBB:—anterior 8·7 mm.; right large IB 7·3 mm. along median line, 9·3 to posterior angle; length of posterior suture 7·3 mm.

Basals bounded by fairly distinct sutures, emphasized by the

bands of lighter colour that accompany them (Pl. XC. fig. 3). The measurements in millimetres are :—

	Width below.	Greatest width.	Width above.	Height.
post. B .....	10·5	12·3	11·8	13·7
r. post. B .....	10·0	11·6	9·6	12·5
r. ant. B .....	8·7	11·0	9·3	12·7
l. ant. B .....	8·7	10·9	9·5	13·5
l. post. B .....	9·2	11·7	10·3	ca. 13·9

The greatest width of each basal is on a level with its umbo, at a little more than half its height. The umbo is most prominent in the posterior basal, which is also the widest of the basals and would be the highest were it not truncated by the periproct.

Radials sloping from top of basals to the peristome rather suddenly. Height of each from the lower angle to the inner margin of the peristome about 8 mm. Width of each below about 8·3 mm.; width above about 2 mm.

The upper margins of the radials form a distinctly pentagonal border to the dorsal cup (Pl. XC. figs. 1, 2). Each side of the pentagon forms a smooth slightly raised rim, and is about 2·3 mm. long. At each angle of the pentagon lies a brachial facet.

Facets rather worn, so that their precise constitution cannot be detected. A ventral groove leads downwards into the cavity of the cup. From this to the outer edge of the facet is about 1·5 mm. Width of facet about 1·3 mm. Neither muscle-fossae nor an axial nerve-canal can be detected.

Within the pentagonal rim, the edges of the radials slope steeply downwards into the cavity of the cup (*cf.* Pl. XC. fig. 5). The downward extension appears to be greater near the facets than near the interradial sutures, and may have served for the attachment of muscles. There is no trace of any tegmental or oral plates, or of any sutural surface on which they might have abutted. This fact and the contraction of the cup at its upper end lead one to regard the pentagonal opening as a peristome, covered in life only by oral folds of a flexible and thinly-plated or naked integument. Below the left posterior facet, in the peristomial cavity, is a fragment of a plate, but its nature is not clear.

The Periproct (Pl. XC. fig. 1) truncates the uppermost angle of the posterior basal with an obtuse re-entrant angle, 2·8 mm. across, and cuts into the adjacent lower angles of the right and left posterior radials with a curve of approximately the same chord (2·8 mm.), also somewhat angular, so that the outline is approximately an irregular hexagon nearly 3 mm. high. Of



anal plates no trace remains, but the relatively large size of the opening suggests that some probably existed.

Ornament:—Beyrich says "Sämmtliche Platten sind aussen glatt und scheinen zum Theil von porösem Gefüge zu sein." Rothpletz remarks that his smaller specimen "die poröse Structur der Platten, welche Beyrich an seinen stark abgeschliffenen Exemplare nur vermuthen konnte, sehr deutlich zeigt." As a matter of fact, the holotype is only "strongly worn down" in one or two places, and it shows the texture of the plates (Pl. XC. fig. 6) no less clearly than the specimen described by Rothpletz. The latter author continues:—"Die Porosität der Platten wird erkannt an den abwechselnden kleineren und grösseren rundlichen Vertiefungen, welche die Oberfläche bedecken. Die kleinen Poren stehen regelmässig und dicht gedrängt, die grösseren liegen vereinzelt dazwischen und häufen sich auf den Radialia nahe den Ansatzstellen und auf den Parabasalia in der Gegend der Buckel." This account applies equally well to the holotype; but I must add that in neither specimen can I detect any regularity of arrangement in the smaller pores.

The diameter of the smaller pores is about  $\cdot 075$  mm. or more. The diameter of the larger pores is  $\cdot 3$  mm. or less. There is every gradation between these sizes.

This micro-structure of the test is so unusual, if not unique, in its absence of regularity and in the sporadic occurrence of larger pores, that Beyrich's use of the word "scheinen" may have been due to a hesitation as to the true nature of the appearance. The irregular surface, especially in the umbonal region of a basal, markedly resembles some encrusting hydrozoon with autopores and dactylopores. Were the appearances really due to some such encrustation, this would not have been the only occasion on which an echinoderm plate has been described as porous on similar evidence. But in the present instance, where the rough surface has been worn down, the same porous structure is still seen penetrating the plates. The pores are rendered distinct by the infiltration of a reddish iron colouring.

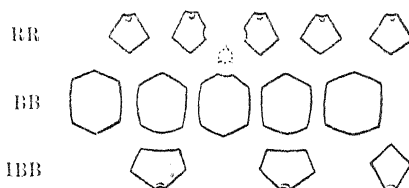
Since the matrix itself is of a granular micro-crystalline composition, with darker specks, it is very difficult to discriminate between the matrix and the rough surface of the plates. Beyrich may have been uncertain whether he was looking at the actual stereom or at an imperfectly cleaned surface. The porous substance is of a saccharoidal appearance, and is easily scraped or broken with a needle, even with a brass pin. It does not cleave with a smooth fracture, as does the denser stereom near the sutures.

This apparent porosity of the test doubtless weighed with those authors who referred *Hypocrinus* to the Cystidea, but the structure is really nothing but an exaggeration of that seen in the cup-plates of the larval *Antedon* before the connective strands of stroma have impressed on the stereom a radiate or fasciate arrangement. The exaggeration consists partly in the greater size of the pores, which, as figured by W. B. Carpenter

in his classical memoir (1866, Phil. Trans. B, vol. 156, pl. 41), have, in the "cribriform films" of *Antelon*, a maximum diameter of  $\cdot 02$  mm., as contrasted with  $\cdot 3$  mm. in *Hypocrius*; partly in the greater relative thickness of the plates. But, so far as I can make out, in a place where the stereom was already worn, the inner layer, or hypostereom, was much denser, so that the pores nowhere pass right through the test.

**Description of the Specimen figured by Rothpletz.** (Pl. XC. fig. 5 & text-fig. 159.)—In its main features this agrees with the holotype, and only the points of difference need here be mentioned.

Text-fig. 159.

*Hypocrius schneideri*.

Analysis of the cup in the specimen figured by Rothpletz.

The periproctal outline is dotted in. Nat. size.

Height 13.5 mm. Posterior basal not so prominent, partly, perhaps, because worn down. Greatest sagittal diameter 13.2 mm. Greatest transverse diameter 13.3 mm. These both at about 8 mm. from basal plane.

Stem-facet obscure, but appears irregularly triangular, the angles directed towards the sutures between the infrabasals. Greatest external diameter (in direction of l. ant. suture) circa 2.7 mm. No trace of radiating grooves.

Infrabasals. The left larger one is considerably cracked, and some of the cracks in part coincide with the sutures; otherwise all the sutures are very hard to trace. Heights of IBB: anterior 6.6 mm.; right large IB 5.1 mm. along median line, 5.8 mm. to posterior angle; length of posterior suture 4.7 mm.

Measurements of Basals in millimetres:—

	Width below.	Greatest width.	Width above.	Height.
post. B .....	6.6	7.0	6.8	8.4
r. post. B .....	5.7	7.0	6.1	8.6
r. ant. B .....	6.1	8.5	7.4	9.0
l. ant. B .....	6.6	7.1	6.7	8.7
l. post. B .....	6.1	7.5	6.1	7.8

It will be noticed that the width is here on the anterior, rather than on the posterior, side.

The Radials have a height of circa 5.4 mm., a width below of 6.6 (v. ant.), 6.3 (ant.), 5.7 (l. ant.), and a width above of circa 1.7 mm.

The Facets (Pl. XC. fig. 5), with their ventral grooves, are rather clearer than in the holotype, but still no muscle-scars can be detected. From the cavity of the cup to the outer edge of each facet is circa 1 mm., and this is also the width of each facet.

The Periproct has a rather more regular shape than in the holotype, and its upper angle is slightly produced adorally. The height of the opening is 2.4 mm., the width 2 mm.

“HYPOCRINUS” PIRIFORMIS. (Pl. XC. figs. 7-10; text-fig. 160.)

1892. *Hypocrinus* (?) *pyriformis* A. Rothpletz, 1892, p. 75, pl. x. f. 23.

As will appear from the description, this species must be placed in a new genus. So long as the imperfect holotype was the only available specimen, the curious features of its structure might be interpreted as abnormalities, and the proposal of a fresh name was scarcely justified. The material obtained by Dr. Wanner and the facts which he has very kindly communicated to me render a more precise interpretation possible and necessitate a new genus. That Dr. Wanner may not be deprived of the fruits of his own discoveries, I leave to him the privilege of giving it a name and of completing my imperfect description.

**Holotype.**—The unique specimen figured by Rothpletz and preserved in the Mineralogisch-Geologisch Instituut te Utrecht.

**Locality.**—Ajer Mati, S. of Kupang, Southern Timor. Dr. J. Wanner has recorded this [or possibly an allied] species from Fatu Bitau (or Bitau) in Insana district, Timor (Centrbl. f. Mineral. 1910, p. 737).

**Description of Holotype.**—A dorsal cup with no trace of stem, anal plates, or tegmen. Stained pinkish. Matrix fragmentary organic limestone with crystalline cement. General shape elongate-pyriform; somewhat irregular owing to peculiarities in the radial circle; with a tendency to be flattened along the per-radial meridians, or, conversely, to be broadly ridged along the interradial meridians, from the top of the basals downwards. This produces a sub-pentagonal cross-section. Height circa 43 mm. Greatest sagittal diameter 28 mm. Greatest transverse diameter 31.5 mm. These diameters are measured by callipers with the jaws parallel to the main axis of the cup; but the diameters are not at right angles to the main axis. On the left-hand side the greatest projection is 26.7 mm. above the basal plane, on the right-hand side it is 24.5 mm.

The Stem-facet was broken away, and the proximal end of the cup was therefore slightly ground down by Dr. Rothpletz (Pl. XC. fig. 7), who says that it “lässt in der Mitte einen Centralcanal erkennen, von welchem die drei Nähte der Basalia [*i. e.* IBB]

ausstrahlen. Nahe der Peripherie liegen fünf rundliche Poren in den letzteren, von denen eine auf das kleinere, je zwei auf die grösseren [Infra-]Basalia fallen. Dies dürfte für die ursprüngliche Anlage von fünf [Infra-]Basalia sprechen, von denen je zwei nachträglich erst verwachsen sind." The cross-section of the worn end is not regularly circular: the sagittal diameter is 7.4 mm., the transverse diameter 6.6 mm. The diameter of the stem-facet may therefore be taken as about .25 that of the cup. The supposed "Centralcanal" is of irregular outline and is far from "in der Mitte," since its centre lies at 2.7 mm. from the posterior side and 4.7 from the anterior side. Proceeding from this irregular area are three cracks, which, however, do not appear to reach the periphery precisely at the points where it is cut by the sutures between the three infrabasals. Under careful lighting one can detect traces of sutures continuing those on the posterior side, and they seem directed towards a point more strictly central than the supposed axial canal. The "fünf rundliche Poren," which represent the axial nerve-canals, are not quite so obvious as might be supposed. They are irregular in shape, size, and position, and that in the small infrabasal lies at the outer edge of a long depression, which seems to have been regarded by the draughtsman of Dr. Rothpletz (Taf. x. f. 23 b) as formed of two pores. That figure has the small infrabasal towards the observer.

Infrabasals closely united. By removing a little more of the firm adherent matrix, I have been able to make the sutures clearer, so that the proof of their position no longer rests on the doubtful appearances of the proximal end. The axis of the small infrabasal is in a line with the periproct. Heights of IBB:—small IB 15 mm.; right large IB 14.4 mm. along median line, 15.1 to upper angle; length of suture between the large IBB 12.3 mm. The infrabasal circlet seems to bear indications of growth-lines parallel with its upper margin and crossing the vertical sutures (Pl. XC. fig. 10).

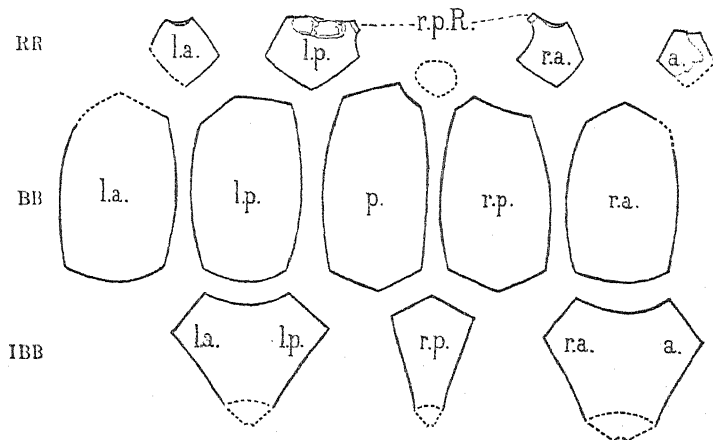
Basals (Pl. XC. figs. 8, 10) bounded by distinct sutures. While all rest symmetrically on the infrabasals, none is quite symmetrical above. The lack of symmetry corresponds with abnormalities in the radials, and will be described in connection therewith. The measurements in millimetres are:—

	Width below.	Greatest width.	Width above.	Height.
post. B .....	12.7	17.1	11.6	26.8
r. post. B .....	13.7	16.8	11.1	ca. 25.6
r. ant. B .....	12.9	17.0	ca. 12.0	24.8
l. ant. B .....	14.5	17.6	ca. 11.0	22.7 +
l. post. B .....	12.0	16.6	12.5	25.3

The greatest width of each basal is at about two-thirds of its height, and here also the sides slope equably to a prominent umbo, above which the plates bend towards the oral pole, the bend being more sudden on the left than on the right.

The Radials (Pl. XC. fig. 9; text-fig. 160) continue the slope of the upper part of the basals. They present several abnormalities due to growth, and are further obscured by crushing. Only four were distinguished by Dr. Rothpletz, but I believe I can see traces of a fifth, though much atrophied [and this is fully confirmed by Dr. Wanner *in litt.*]. Ant. R and l. ant. R were

Text-fig. 160.



"Hypocrinus" piriformis.

Analysis of the cup of the holotype.

The sutures obscured by wear or fracture are represented in dotted line, as is also the outline of the periproct.

*r.p.R.* denotes the minute plates, of rather uncertain number and shape, one or all of which probably represent this radial. On *l.p.R.* the outline of the cleaved surface is represented. The outline of *a.R.* is modified by a slight shear. Nat. size.

apparently of less modified outline than the others, though in this specimen weathering and crushing have rendered that outline incomplete. The l. ant. R rests on l. ant. B by a longer side than that which rests on l. post. B. Similarly, the side of ant. R, resting on the r. ant. B seems to have been longer than that on l. ant. B. Ant. R is broken, and part of it, still united to l. ant. R has been pushed inwards and under the remaining portion. Thus it is difficult to compare the interrarial sutures bounding these two radials, but there is nothing to show that they were not of equal length. The upper margin of each of these radials was excavated by a concave curve, and the edge

was slightly bevelled so as to give this the appearance of a very obtuse angle, with its apex about in the middle line of the radial. This appears to represent a greatly simplified brachial facet, but there are no articular markings, unless it be a slight depression near the middle.

The r. ant. R was similar in its general outline to the ant. and l. ant. RR, having, like them, the basiradial suture longer on the posterior than on the anterior side. It differs, however, in that its left or posterior side is divided into two tracts: one a very short suture connecting the upper angle of the plate with what seems to be part of the r. post. R; the other an excavate margin to the periproct. The curve of this margin throws the left upper portion of the radial away from the median line, so that the sub-angular concavity of the facet is longer on the left than on the right.

The r. post. R is probably represented partly by a small fragment still attached to r. ant. R and partly by a fragment attached to l. post. R. The right-hand fragment has been pushed slightly inwards. Whether these fragments all represent the r. post. R, whether a part or the whole may not represent anal or perisomic plates, are questions that cannot be settled on the evidence of this specimen. [Dr. Wanner *in litt.* confirms and extends my observation of some small plate or plates in this position, one of which, at any rate, he identifies with r. post. R.] The really important fact is that r. post. R has been so far atrophied that we may safely infer the entire absence of any r. post. arm.

The l. post. R is, in every direction, larger than the others. It rests, almost symmetrically, on the shoulders of the l. post. and post. BB and abuts normally on l. ant. R. On its right (*i. e.* posterior) side, however, the radial in its lower part bounds the periproct, and in its upper part has a short sutural union with the supposed r. post. R. The upper, or peristomial, margin is regularly concave, with a slightly more marked curvature than that of the other radials, but shows no bevelling, groove, or depression, such as might suggest an articular facet. Outside this margin, however, the highest part of the plate rises into a mass of calcite (possibly stereom), which has been truncated by a cleavage-fracture, sloping slightly downwards and outwards from the oral pole. The evidence of the holotype leaves it uncertain whether this protuberance formed the base of a mere hump, of an unjointed spine, or of an arm; but Dr. Wanner tells me that some of his specimens permit "die sichere Beobachtung, dass l. p. R eine Gelenkfläche für einen Arm zeigt," and his diagrams show that this joint-face corresponds with the cleavage-surface just described. It will be interesting to learn the exact constitution of this facet, whether it has a fulcral ridge and axial canal, and whether there is a ventral groove leading down to the peristome. Of such structures the holotype presents no trace whatever.

The projection of this facet is due not merely to the protuberance on the radial, but also to the greater height of that radial and of the subjacent posterior basal. The sum of these heights is again relatively exaggerated by the nearer approach of the left posterior side of the theca to the vertical as compared with the right anterior side, which bulges outward. Thus the oral surface of the theca slopes downwards from the left posterior perradius towards the right anterior interradius. If the erect position of the stem be admitted, then all these departures of the theca from the normal symmetry result in raising the supposed large l. post. arm further and further from the sea-floor.

The evidence thus far does not absolutely warrant the conclusion that the r. ant., ant., and l. ant. arms had become atrophied out of existence, or even that they were so reduced as to be useless as food-collectors; but it does lead us to infer that the task of sending a food-stream to the mouth was mainly, if not entirely, thrown on the l. post. arm.

The following are measurements of the radials in millimetres:—

	Height.	Width below.	Width above.	Left lower margin.	Right lower margin.
r. ant. R .....	7.5	9.4	5.3	8.1	4.5
ant. R .....	?	?	5.3 preserved.	?	?
l. ant. R .....	8.9	7.0 to edge of periproct.	3.4 or 4.4	?	5.4
l. post. R .....	9.3	11.7	5.5	7.6	8.3

Peristome (Pl. XC. fig. 9).—The measurement "width above" indicates how much of each radial enters into the peristomial margin. The opening is "elliptische," as Rothpletz describes it, only because the plates are shifted; probably it was of irregular outline, with an angle about the middle of each of the four large radials, and a longer side in the posterior region.

One would like to know how this peristome was closed: by oral plates, by other plates of interrarial position, by enlarged cover-plates of the left posterior arm, or, as seems highly probable, by the brachials of the reduced arms of the trivium.

Periproct (Pl. XC. fig. 9).—Dr. Rothpletz regarded the subcircular or subhexagonal opening between the post. and r. post. BB, and the l. post., r. post., and r. ant. RR as the periproct. He did not observe all the difficulties to which this interpretation led, such as the apparent absence or almost complete atrophy of a radial, or, still more, the unusual position thus assigned to the small infrabasal, or even the necessary conclusion

that his species could not be a *Hypocrinus*. So long as there was only one specimen known, it might have been legitimate to evade some of those difficulties by a vague hypothesis of abnormality, or, more precisely, to have supposed that the anus occupied its usual position opposite the small basal (which region is worn away in the holotype), but that it had become choked, and that a new outlet had been formed by the partial resorption of that radial which in the present paper is called r. post. R, but which, on that interpretation, would have been ant. R. When, however, Dr. Wanner informs me that all his new specimens agree in this curious position of the opening, and that none of them shows any trace of an opening on the opposite side of the theca, then I am bound first to accept the identification by Rothpletz, and afterwards to face the difficulties involved.

The measurements of the periproct in millimetres are: height 5; width below, 5.4; left lower margin 3.9; right lower margin 2.7.

There is no trace of any periproctal plates, unless they are to be sought in the minute plates between the left posterior and right anterior radials.

Ornament.—In addition to the growth-lines already mentioned, there are to be seen on the better-preserved infrabasals, *i. e.* on the posterior side, traces of pustules, apparently coinciding with the growth-lines. There also seem to be similar pustules on a small tract of the posterior basal. The rest of the surface is too badly preserved for the ornament to be detected. Dr. Rothpletz says that “die durchweg abgeriebenen Platten lassen ihre poröse Beschaffenheit zwar noch erkennen.” They are, however, far from presenting the curious appearance of *H. schneideri*, and on the better-preserved portions no pores can be observed. Most of the surface is irregularly worn and contains numerous holes. These latter, however, are either due to some boring organism or to the impression of hard particles in the matrix. Often the hard particles, which may be grains of a dark mineral or fragments of other fossil organisms, are still seen closely adherent to the cup-plates, or even forced into them.

**Affinities of “*H.*” *piriformis*.**—Comparison of the analyses shows at once that this species is not a *Hypocrinus*. The position of the small infrabasal, the relations of the periproct to the posterior basal and to the superjacent radials, and the modifications of all the radials, are considerable distinctions.

It is even doubtful whether the species should be referred to the Gasterocomidæ, although it agrees with the diagnosis of that Family, as given above, in all the known essential features except in the shape of the radial facets. No other Gasterocomid, however, has the infrabasals arranged in quite the same way. These two points demand closer scrutiny.

The position of the small infrabasal in the right posterior radius is characteristic of *Flexibilia Impinnata* rather than of *Dicyclica Inadunata*. When the latter forms have a tripartite



base, the small IB is usually anterior, as in *Hypocrinus*. A few other positions for it have been recorded, but not, so far as I can find, the same as it occupies here, unless it be in the little-known *Ampheristocrinus* Hall (1881) from the Niagara group of Indiana.

The radial facets of the Gasterocomidæ are of the horse-shoe shape so common in Cyathocrinoidea. In "*H.*" *piriformis* the facets are so greatly modified that it is perhaps unsafe to base conclusions on them. The arm-bearing facet seems to have occupied almost the full width of the peristomial margin of the left posterior radial in the holotype; but the diagram Dr. Wanner has sent me shows it as occupying about half the width. There is, in the holotype at any rate, no trace of the axial canal. The other facets are atrophied, it is true, but such traces of them as there are seem to indicate a pre-existing facet as wide as the radial rather than one of horse-shoe outline. Wide facets are, of course, almost universal in the Flexibilia Impinnata, though not confined to that group.

If the reference of "*H.*" *piriformis* to the Flexibilia be taken as a possible hypothesis, we have next to inquire whether in that Order the periproct ever emerges below the summit of the radials. I am unable to find that such an arrangement has ever been described in any known genus, but that is no valid argument against the possibility. Among Dicyclica Inadunata this peculiar position first appears suddenly in the Devonian, and I have already hinted at the possibility of its independent reappearance towards the close of the Carboniferous. Why, then, should it not have appeared with equal suddenness in some other group, especially when the form displaying it is peculiarly specialized in other respects?

Here, moreover, some actual corroboration of the hypothesis is afforded by the fossil which impelled me to make this first-hand examination of *Hypocrinus*. That is a small cup or patina from the uppermost bed of the Yoredale series, in Nidderdale, Yorkshire. On it is based the new genus and species *Cydonocrinus parvulus* (Bather, Oct. 1913).

*Cydonocrinus* belongs to that group of Flexibilia in which, to use Dr. Springer's words, "the rays and their divisions are rounded exteriorly, and the interbrachial spaces relatively depressed" (Journ. Geol. vol. xiv. p. 510, Oct. 1906). This character affects also the anal plates, which are "not united by suture with adjacent rays, but in arm-like series, more or less separated from them by perisome" (Springer, *op. cit.* p. 519). Such forms constitute the Taxocrinidæ as defined by Dr. Springer, and it is clear that, of the included genera, *Cydonocrinus* is most nearly allied to *Taxocrinus*. Thus it has the same fundamental plan of the cup as has "*H.*" *piriformis*.

Now the features in which *Cydonocrinus* differs from *Taxocrinus* all bring it nearer to "*H.*" *piriformis*. They are the

subglobular shape of the cup, the small diameter of the stem-facet, the relatively large size of the infrabasals, which in the *Flexibilia* are rarely visible, the rise of the radials towards their facets curiously resembling the hump of the arm-bearing radial in "*H.*" *piriformis*, the crowding of the facets round the peristome which thus becomes relatively small, and, finally, of greatest interest in this connection, the outward projection of the posterior basal, which, combined with the constriction of the upper part of the cup, almost entirely separates the rectal channel from the general thecal cavity. In the actual fossil the anal plates, which once rested on the posterior basal, have been broken away, so that the appearance is that of a periproct, opening at the top of the posterior basal and at the lower corners of the adjacent radials.

Given, then, the existence of such a form in Middle Carboniferous times, it is easy to see how the accentuation of the left posterior radial with its arm would have pushed the periproct further to the right, and crowded out the right posterior radial. This and the diminution of the other arms would have produced a form agreeing with "*H.*" *piriformis*. On this hypothesis some of the minute plates between the left posterior and right anterior radials may be relics of the perisomic plates.

Physiologically considered, a modification bringing the food-intake so close to the vent would be curious in any group of crinoids; but that such a modification would not be altogether out of character with the *Flexibilia* may be gathered from a perusal of two suggestive paragraphs by Dr. Springer (*Journ. Geol.* vol. xiv. pp. 496, 497, 1906). Speaking of "that strange influence which has modified the bilateral symmetry of almost every genus in this entire group," he points out that "if the arms have an asymmetrical distortion, it is to the right, never to the left." If the anals are shifted, it is likewise to the right, so that the excavation of the posterior basal for their reception is "on the right shoulder of the plate."

Timor is a long way from Britain, and I am not going to say that the genus which must be established for "*H.*" *piriformis* is necessarily descended from the genus to which our Yorkshire fossil belongs; but I do claim to have shown some reason for thinking that "*H.*" *piriformis* may belong to the *Taxocrinidæ*, and that, peculiarly modified though it is, its very modifications are exaggerations of a tendency natural to that Family.

Accepting this systematic position, at all events until it is proved erroneous, we may draw up the following:—

**Generic Diagnosis.**—A *Taxocrinid* with no radianal, with large IBB forming a conspicuous part of the cup, with left post. R and arm enlarged and all others reduced in size, the right post. R being almost entirely atrophied, so that the rectum passes between post. and r. post. BB below and l. post. and r. ant. RR above.

## SUMMARY.

The two specimens of *Hypocrinus schneideri* Beyr., described by Beyrich and Rothpletz respectively, are redescribed and refigured. The structure of the genus is shown to agree with that of the Devonian family Gasterocomidæ, but it is suggested that in this case and in that of "*Lecythiocrinus*" *adamsi* the distinctive features may have been independently acquired.

The holotype of "*Hypocrinus*" *piriformis* Rothpletz is re-described and refigured, and proved to be no *Hypocrinus*. It is thought to be a highly modified descendant of the Taxocrinidæ, by way of such a genus as *Cydonocrinus*. The left posterior radial appears to have borne a large arm, but the other arms were more or less atrophied, and the right posterior radial has almost disappeared.

## EXPLANATION OF PLATE XC.

*Hypocrinus schneideri* Beyr.

Figs. 1-4 are photographs of the holotype, enlarged slightly less than 2 diameters.

- Fig. 1. View to show the relations of the periproct, which is the opening nearest the observer.  
 Fig. 2. View from above the oral pole, showing the peristome and radial facets.  
 Fig. 3. The cup from the right side: *o.*, oral pole; *a.*, anal opening or periproct. Note the light colour of the dense stereom at the sutures, contrasted with the staining of the porous stereom of the general surface.  
 Fig. 4. The cup from below, with the posterior interradius away from the observer. Note the sutures between the infrabasals.  
 Fig. 5. A photograph of the peristomial area of the specimen figured by Rothpletz. The periproct is at the lower corner of the figure.  $\times 5$  diam.  
 Fig. 6. Micro-photograph of the upper part of one of the basals in the holotype.  $\times 7$  diam.

*"Hypocrinus" piriformis* Rothpletz.

- Fig. 7. The ground-down base of the holotype, photographed under water, so as to bring out the sutures between the infrabasals and the five axial nerve-canals in those plates (see detailed description on pp. 905, 906). The orientation is as in fig. 4, and approximately opposite to that of Rothpletz, pl. x. f. 23 b.  $\times 4$  diam.

Figs. 8-10. Photographs of the holotype, nat. size.

- Fig. 8. Shows the posterior basal with the protuberant left posterior radial (l. p. R.) above it and the periproct at its right upper corner.  
 Fig. 9. View from above the oral pole, showing the distorted peristome with the large but obscure facet of left post. R. to the left, and the anal opening towards the observer.  
 Fig. 10. The basal facing the observer is the right anterior. Above it is the peristome (*o.*), with the left post. R. rising up behind it, and with the anal opening (*a.*) to the left. Note the ornament of growth-lines in the lower part of the cup.

All the photographs were taken by Mr. H. G. Herring, and represent a selection from many attempts upon these difficult subjects.

[Note. The following corrections were received too late for insertion in previous sheet:—

Page 896, line 15 from bottom } For *Hypocrinus mülleri*.  
 Page 800, " 19 " " } Read *H. mülleri*.

EDITOR.

52. On Freshwater Decapod Crustacea (Families Potamonidæ and Palæmonidæ) collected in Madagascar by the Hon. Paul A. Methuen. By W. T. CALMAN, D.Sc., F.Z.S.†

[Received October 8, 1913: Read November 11, 1913.]

(Plates XCI. & XCII.‡ and Text-figure 161.)

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#### INTRODUCTION.

The collection described in this paper was obtained in Madagascar in 1911 by the Hon. Paul A. Methuen, to whom I am indebted for the opportunity of examining it. The specimens are the property of the Transvaal Museum, Pretoria, but, by permission of the Acting Director of that institution, a selection from among them, including the holotype of the new species, has been retained for the British Museum.

For the purpose of comparison with Mr. Methuen's material the specimens of Potamonidæ and Palæmonidæ from Madagascar already in the British Museum collection have been re-examined and the results have been incorporated in the paper.

The following is a list of the localities whence Mr. Methuen's specimens were obtained. Those from the localities marked with an asterisk were collected for Mr. Methuen by M. Herschell-Chauvin of Tamatave:—

#### *Eastern Region of Madagascar.*

Manambato, streams running into Lake Rasoabé. July, 1911.

Ambilo, streams running into lagoon. July, 1911.

\*Rapides de l'Ifofoty, à deux jours de Tamatave. September, 1911.

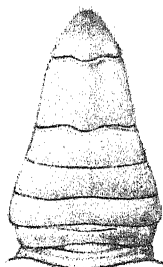
\*Ivondro. August, 1911.

† Published by permission of the Trustees of the British Museum.

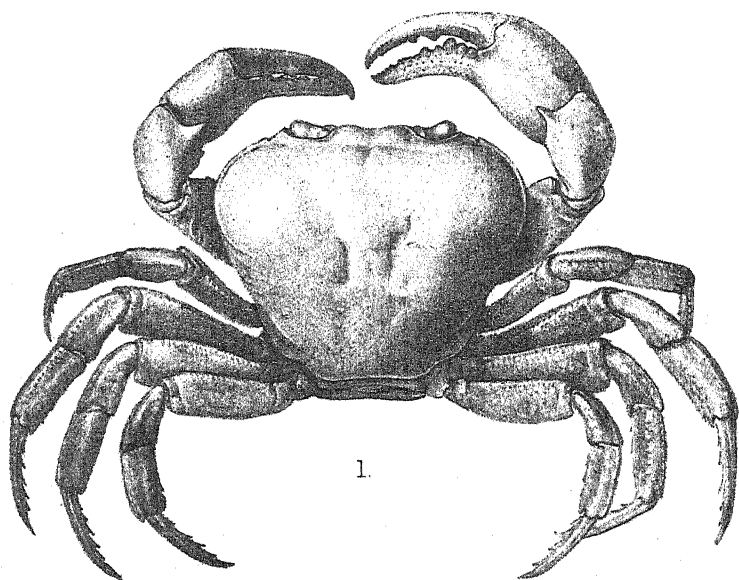
‡ For explanation of the Plates see p. 932.



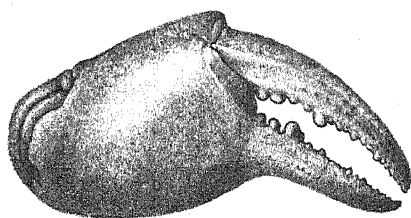
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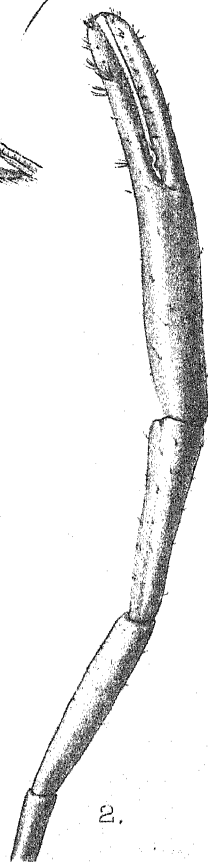
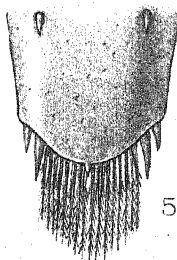
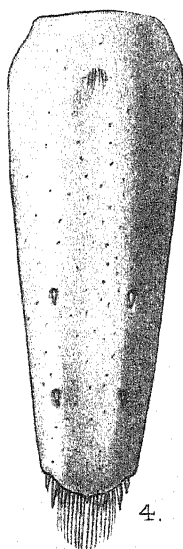
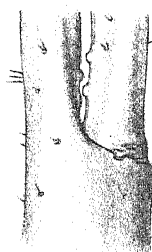
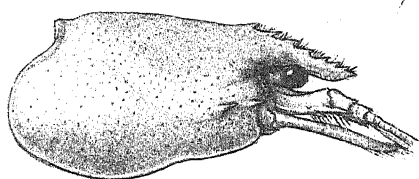
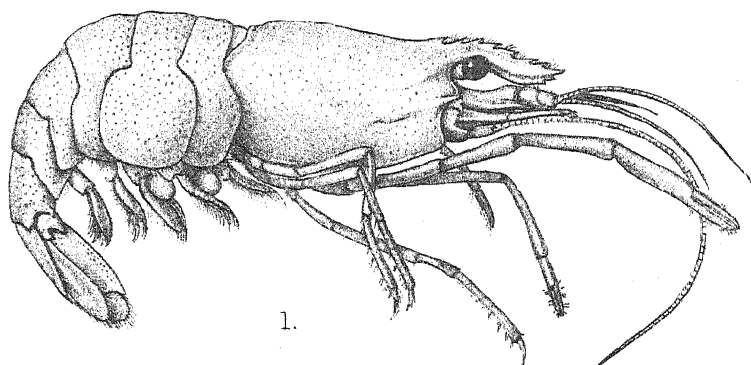
2.

G.M. Woodward del. et lith.

Huth imp.

POTAMON METHUENI.





G.M. Woodward del. et lith.

Huth imp.

*PALEMON HILDEBRANDTI.*





*Mountains leading to the Mangoro Terrace.*

Ambatonharanana, near Ampasimpotsy. July, 1911.

*Mangoro Terrace.*

Imerimandroza, northern end of Lake Alaotra, altitude 800-900 metres. July 1911.

*Mountains leading directly to the Plateau.*

Ambohidratrimo. June, 1911.

*South-western Region.*

Andranolaho and Tongoroby, Onilahy River, Dist. of Betsioky. October, 1911.

## PART I.—Family POTAMONIDÆ (River-Crabs).

1. *Description of the Material.*

The River-Crabs of Mr. Methuen's collection are referred to the following species:—

*Potamon* (*Potamon*) *madagascariense* A. Milne-Edwards.

“ “ *goudoti* H. Milne-Edwards.

“ “ *methueni*, sp. n.

*Hydrothelphusa* *agilis* A. Milne-Edwards.

As will be explained below, the specimens included under the first of these names differ considerably among themselves and represent at least three distinct forms which may possibly deserve to rank as varieties or even as species.

In the specific descriptions which follow, regard has been given chiefly to the characters of the carapace, to the exclusion of those of the appendages, since the latter seem to afford no useful points for separating the species here dealt with. Attention may perhaps be called to the difficulty of deciding whether any single specimen is to be regarded as adult. In the case of females the broadening of the abdomen seems to afford a fairly definite indication, and it is usually easy to sort the specimens into “adults” and “immature.” In the males, however, the genital appendages of the first and second abdominal somites are often found apparently well developed in very small individuals, which differ considerably in the outline of the carapace from larger males.

In the lists of specimens the numbers preceded by the letters “B.M.” refer to the British Museum Register of Crustacea. The measurements given in the tables are expressed in millimetres and were taken by means of a scale graduated to .5 mm. No very high degree of accuracy can be claimed for them, but I believe that they are fairly comparable among themselves; it is not in all cases certain that they can be directly compared with

measurements given by other writers, owing to the frequent lack of precise indication of the points between which measurements have been taken. In those given here "length" is measured from the hinder edge of the carapace to the front in the median line, *i. e.*, to the bottom of the notch between the frontal lobes; "breadth" is the greatest breadth of the carapace wherever it may be; "exorbital width" is the distance between the tips of the exorbital teeth, and is therefore least accurate where these points are blunt and indefinite; "frontal width" is the most difficult of all to find fixed points for, owing to the obliquity of the sides of the front; the measurements here given have been taken between the innermost points of the orbits, *i. e.*, just above the antennal flagella, when the carapace is viewed from in front.

Complete references to the earlier literature relating to the species dealt with will be found in Miss Rathbun's monograph, to which I am glad to acknowledge my great indebtedness.

POTAMON (POTAMON) MADAGASCARIENSE A. Milne-Edwards.

*Potamon (Potamon) madagascariensis* A. M.-E., Rathbun, Nouv. Arch. Mus. Paris, (4) vi. 1904, p. 264, pl. ix. fig. 7.

I have ventured to group under this name a number of specimens which differ considerably among themselves, and of which some at least would probably be regarded by other students as representing distinct species. I have so grouped them, partly as a confession of failure, for I feel no great confidence that they really belong to a single species, although I have found no satisfactory characters by which to distinguish them, and partly in order to emphasize the fact that the various forms can be arranged, in a way that seems to me significant, around the typical form of the species. They radiate outwards from this typical form towards the other species of Potamonidae recorded from Madagascar, and while in some cases there remains enough of a gap to justify the retention of the names given to these other species, the relations are clear enough to suggest for the Madagascar River-Crabs an autochthonous origin from some form resembling the typical *P. madagascariense*. Miss Rathbun, in her monograph, attributes a certain range of variation to this species, and notes that one of the forms shows a transition towards *P. humbloti*. If the view here put forward be correct, the range of variation must be considerably extended, and *P. humbloti*, *P. grandidieri*, and *P. bombetokense* must be included as varietal forms.

The specimens examined appear to fall naturally into five series as shown on the accompanying table of measurements. To avoid prejudging the question of their systematic rank, I designate these series by letters.

Measurements of *Potamon madagascariense*.

Locality, &c.	Sex.	Length.	Breadth.	Exorbital width.	Frontal width.	Breadth ratio.
SERIES A.						
Madagascar, B.M. 81.9 .....	♂	50	66	45	20	1.32
" B.M. 85.18 .....	♂	30.25	39	28	12	1.28
" " .....	♂	15.5	21.25	15.75	7	1.37
" " .....	♂	11	14.5	11.75	5.25	1.31
" " .....	♂	10	12.5	10	4.75	1.25
" B.M. 79.20 .....	♂	16.75	22	15.5	7.25	1.31
" " .....	♂	13.5	17.25	13	6	1.27
" " .....	♂	13	16.75	12	5.5	1.28
" " .....	♂	12.75	16	12.5	5.5	1.25
Etsileo, B.M. 82.6 .....	♂	25.25	33.5	23	10.5	1.32
" " .....	♂	21	27.5	19.5	9	1.3
" " .....	♂	20.25	26	18.25	8.5	1.28
" B.M. 80.27 .....	♂	28.5	36	24.5	11	1.26
" " .....	♂	20.5	26	19	8.5	1.26
" " .....	♂	19.75	25.75	18.25	8.5	1.3
SERIES B.						
Hotry, Methuen, No. 90 .....	♂	37.5	46.5	33.5	14.75	1.24
" " 91 .....	♂	32.5	38.5	29	13	1.18
" " 92 .....	♂	22.25	26.5	21	9.25	1.19
" " 93 .....	♂	19.5	23.25	18.25	8	1.19
SERIES C.						
Ambatonharanana, Methuen,						
No. 25 .....	♂	16.5	21.5	15	7	1.3
" " 19 .....	♂	16.25	21	15.25	7.25	1.29
" " 27 .....	♂	16	22	15.25	7.25	1.37
" " 23 .....	♂	15.75	20.5	15	7	1.3
" " 21 .....	♂	15.5	20.5	15.25	7	1.32
" " 24 .....	♂	14.5	19	14.25	6.5	1.31
" " 20 .....	♂	14.5	19	14	6.5	1.31
" " 22 .....	♂	13.75	17.5	13.5	6	1.27
" " 16 .....	♂	13.25	17	12.75	6	1.28
" " 26 .....	♂	11	13.5	11	4.75	1.22
" " 15 .....	♂	10.25	13	10.25	4.75	1.26
SERIES D.						
Madagascar, B.M. 88.5 .....	♂	34	45.5	29.5	14	1.33
" " .....	♂	35	45.5	29.5	14	1.3
SERIES E.						
Imerimandrosa, Methuen,						
No. 35 .....	♂	47	57.5	41	17.25	1.22
" " 33 .....	♂	46.5	58.75	39.5	17	1.26
" " 38 .....	♂	45.5	56	38	16.5	1.23
" " 37 .....	♂	38.5	47.5	33.5	14.75	1.13

SERIES A.—These specimens are all, without much doubt, referable to the typical form of *P. madagascariense* as described and figured by A. Milne-Edwards and by Miss Rathbun. The characters in which they differ among themselves are relatively unimportant, with two exceptions, viz. :—(1) the distance between the epigastric and the postorbital crests, which, in the largest

specimen (81.9), is a trifle less than half the distance between the former crest and the frontal margin, is about  $\frac{2}{5}$ ths of that distance in the largest specimen from 85.18,  $\frac{1}{3}$ rd in the largest from 82.6, and only about  $\frac{1}{4}$ th in an adult female from 80.27, while in the smallest specimen from 85.18 the two crests are all but continuous; (2) the roughness of the surface of the carapace, which, in most of the specimens, is in accordance with the published descriptions and figures, becomes notably reduced in the specimens from Betsileo registered under the numbers 82.6 and 80.27; in these, the whole carapace is much smoother, with only a few oblique granules or raised lines near the antero-lateral margins and on the posterior branchial regions, and one or two obsolescent granules on the front; it is to be noted that the granulation or serration of the antero-lateral margins themselves is not correlated with the general roughness or smoothness of the surface, being stronger in the Betsileo specimens than in the much rougher specimens from 85.18.

In the smaller specimens of this series, especially in the two smallest from 85.18, the external orbital notch becomes very shallow or is altogether obliterated, and the outline of the carapace is more quadrilateral than in larger specimens.

SERIES B.—The four specimens of this series differ from those included in Series A in the relative flatness and narrowness of the carapace, which has the antero-lateral borders less arched, so that the lateral projection of the carapace beyond the exorbital tooth is only about  $\frac{2}{3}$ rds of the greatest diameter of the orbit instead of at least  $\frac{5}{6}$ ths as in the larger specimens of Series A. These differences, however, are rather less strongly marked in the larger than in the smaller specimens of this series. The frontal lobes are very prominent in one specimen, and in all there is a tendency for the margin of the front to be less deflexed than in Series A. The exorbital and epibranchial teeth are very prominent, and, although the carapace as a whole is much less rough than in the largest specimens of the first series, the epigastric and postorbital crests are sharply defined and the oblique lines on the lateral regions are numerous, sharply cut, and granulated. The marginal granules on the under surface of the merus of the chelipeds are very prominent and spiniform. It is worth noting that even in the larger of the two males the genital appendages are very short, less than half the length of the abdomen, and apparently immature.

This form or variety seems to me to lead in the direction of *Hydrothelphusa*.

SERIES C.—The largest female in this series is only 16.25 mm. in length, but is apparently adult; the largest male is a trifle larger. The carapace in all is rather convex, especially antero-posteriorly, and the front is bent downwards. The carapace, on the whole, is rather wide, the ratio of breadth to length being, in one specimen, as high as 1.37. The surface is rather smooth,

although not more so than in some specimens of Series A. The epigastric and postorbital crests are somewhat indefinite; in some specimens they are nearly in line, but in others they are separated by a distance estimated at  $\frac{2}{5}$ ths of that between the epigastric and the frontal margin. The exorbital tooth is not prominent and the epibranchial is small.

The specimens of this series approach the *P. humbloti* and *P. grandidieri* of Miss Rathbun's monograph, especially perhaps the latter, although they do not agree exactly with the description of either. They differ so much among themselves in all the characters that might be used to distinguish them from the specimens of Series A, that I cannot regard them as specifically distinct; from Series B they are more easily defined.

SERIES D.—In the two specimens of this series the carapace is very smooth, the rugosities on the anterior part of the branchial region being hardly perceptible. The general antero-posterior convexity of the carapace is well marked, the various regions are also convex, and the grooves between them correspondingly distinct. The most characteristic feature is the inflation of the anterior branchial regions, which, in both, but especially in the female, is much more marked than in any of the specimens mentioned above. The antero-lateral marginal line is not prominent and its granulations are nearly obsolete. In the female the distance between epigastric and postorbital crests is nearly half that between the former and the front, while in the male the proportion is not more than two-fifths.

These specimens, which I cannot believe to be specifically distinct from the smoother specimens of Series A, approach *P. goudoti* in general aspect, and are separated from it chiefly by the character of the epigastric crests, which do not project nearly so far forwards, are much less oblique, and far more clearly disjoined from the postorbital crests than they are in that species.

SERIES E.—This series consists of four large, dark-coloured, male specimens which differ considerably from all those discussed above. The carapace as a whole is moderately convex, with the regions somewhat inflated and the grooves between them well marked. The surface is fairly smooth, with oblique striae on the anterior part and more distinct raised lines on the posterior part of the branchial region. The crests are well defined and sharp, the epigastric well in front of the postorbital. The epibranchial tooth is large and the exorbital moderately prominent.

According to Miss Rathbun's analytical key to the species of the subgenus *Potamon* these specimens would be referred to *P. bombetokense*, described by her from a single male specimen. From the detailed description and figure of that specimen, however, they differ in the rather narrower carapace, in having the margin between exorbital and epibranchial teeth straight or slightly convex instead of concave, and, apparently, in having the inter-regional grooves more strongly marked.

POTAMON (POTAMON) GOUDOTI H. Milne-Edwards.

*Potamon (Potamon) goudoti* H. M.-E., Rathbun, Nouv. Arch. Mus. Paris, (4) vi. 1904, p. 305, pl. xiii. fig. 10.

Measurements of *Potamon goudoti*.

Locality, &c.	Sex.	Length.	Breadth.	Exorbital width.	Frontal width.	Breadth ratio.
Madagascar (no locality), Methuen, No 55.	♂	30.25	41	26.5	12.75	1.35
Betsileo, B.M. 82.6 .....	♂	31.5	42.5	28	13.5	1.35
" " .....	♂	29	39	25.5	11.5	1.34
Antananarivo, B.M. 82.13 ...	♂	29	39.5	26	12	1.36
" " ....	♂	28	38.5	25.25	11.5	1.37
" " ....	♂	27.25	36.25	24.25	11	1.33
" " (dry) .....	♂	29.75	41	26.5	12.75	1.37
" " " .....	♀	29	39.25	25.75	12.5	1.35
" " " .....	♀	28.5	37.5	24.75	11.75	1.31

The nine specimens agree in general with the published descriptions and figures of this species, and present no noteworthy differences among themselves.

POTAMON (POTAMON) METHUENI, sp. n. (Plate XCI.)

Measurements of *Potamon methueni*.

Locality, &c.	Sex.	Length.	Breadth.	Exorbital width.	Frontal width.	Breadth ratio.
Imerimandrosa, Methuen, No. 34.	♂	33	46.25	26.75	12.5	1.4
" " 36.	♂	30.75	43.75	25	12	1.42
" " 39.	♂	28.25	39	24	11	1.38

*Description*.—Carapace: length about five-sevenths of its breadth, very convex, especially from before backwards, gastric region sometimes below level of inflated anterior branchial regions; surface finely punctate, smooth. Oblique portions of cervical groove shallow and obscure, if produced forwards they would cut the line of the postorbital crest rather within the outer angle of the orbit; H-shaped depression well marked; posterior part of mesogastric region wider than urogastric, the latter fairly well defined posteriorly. On the anterior branchial region is a faintly marked oblique ridge nearly parallel to the cervical groove.

Epigastric crests not very prominent, more or less rugose, hardly oblique, situated entirely behind a line joining epibranchial teeth; they are continued, without interruption, into the protogastric portions of postorbital crest, which are very low, rounded, and ill-defined, except in so far as they are limited by the transverse depression behind each orbit; in general direction the postorbital crest is transverse, and it is not traceable external to its intersection by the cervical groove. Groove between the epigastric lobes bifurcating widely behind, the limbs angularly bent so as to become parallel. Front strongly deflexed, but with anterior margin visible from above; divided into two low rounded lobes, most distinct from above, less so from in front; with a smooth raised marginal line. Upper margin of orbit with a prominent smooth border, inclined forwards, with only a faint trace of a lobe in the middle, towards the exorbital angle which is not at all prominent or dentiform. Lower margin of orbit nearly straight as seen from below, and smooth or obscurely crenulated; without any trace of a notch or sinus below the exorbital angle. Antero-lateral margin strongly arched, with a distinct marginal line, which is smooth or, in the smallest specimen, obscurely crenulate, and runs on to dorsal surface behind. Postero-lateral border concave, with more or less distinct lines. Pterygostomial region and, less conspicuously, subhepatic region beset with tubercles.

Merus of third maxillipeds slightly wider than long; ischial groove rather nearer the inner than the outer margin.

Chelipeds unequal. Lower surface of merus margined with tubercles, which may become indistinct; a small blunt tooth near distal end of inner edge; upper edge rugose with a low subterminal tubercle. Carpus smooth and punctate externally; with two teeth on inner side and a variable number of small granules. Surface of hand smooth and rather coarsely punctate; fingers long, slender, and strongly deflexed.

Sixth somite of male abdomen shorter than its distal width.

*Holotype*, male, 33 mm. in length, in British Museum. *Paratypes*, the two other males mentioned above, in Pretoria Museum.

*Remarks*.—This species resembles, on the one hand, *P. goudoti* and, on the other, the smooth form of *P. madagascariense* described under Series D above. From the former it differs chiefly in the wider carapace (the concavity of the postero-lateral borders has the effect of increasing the apparent difference in this respect); in having the epigastric crests nearly transverse, lying behind instead of in front of the line joining the epibranchial teeth, and quite continuous with the obsolescent postorbital crests; in having the gastric region less elevated and the transverse convexity of the carapace therefore less marked; and in having no notch below the external orbital angle. Compared with *P. madagascariense* the same differences hold good, even although in that species the epigastric crests are less oblique and less advanced than they are in *P. goudoti*.

## HYDROTHELPHUSA AGILIS A. Milne-Edwards.

*Hydrothelphusa agilis* A. M.-E., Rathbun, Nouv. Arch. Mus. Paris, (4) vii. 1905, p. 266, pl. xvii. (Potamonidæ, xv.) fig. 7.

Measurements of *Hydrothelphusa agilis*.

Locality, &c.	Sex.	Length.	Breadth.	Exorbital width.	Frontal width.	Breadth ratio.
Ambatonharanana, Methuen, No. 10	♀	32	36.5	27.5	12.5	1.14
" " 11	♂	23.5	32.5	25.5	11.5	1.14
" " 12	♂	29.5	33.5	25.5	12.25	1.13
" " 13	♀	30.5	34.5	26.5	12.5	1.13
" " 14	♂	31.75	36.25	27	12.5	1.14
Ambohidratrimo, Methuen, No. 28	♀	27	31.25	23.5	11	1.15
" " 29	♂	31.5	38	27	13.5	1.2
" " 30	♀	38.5	45.5	32.75	15.5	1.18
" " 31	♀	27.5	32.5	23.75	11.5	1.18
" " 32	♂	26	30.25	22.75	10.25	1.16

The arrangement of the spinules on the lower orbital margin is less regular and constant than is implied by Miss Rathbun's description. In other respects the specimens agree well with the published accounts of this species. All the female specimens, with the exception of No. 30, are clearly immature.

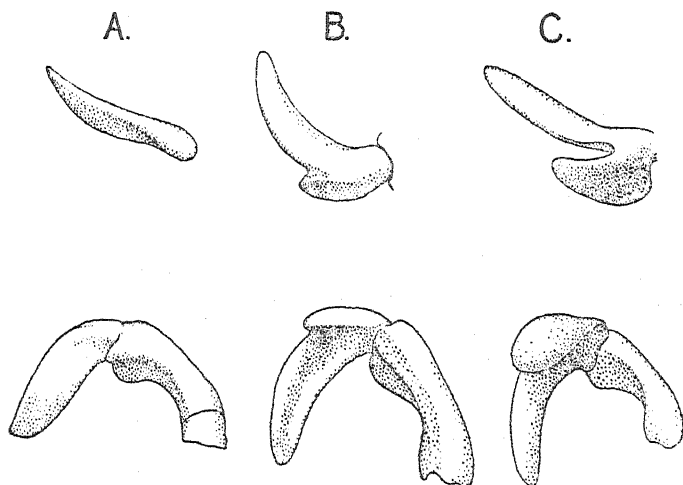
2. *Systematic Affinities of the Madagascar River-Crabs.*

In his monograph of the Indian River-Crabs (Cat. Crust. Indian Mus. pt. i. fasc. ii. Potamonidæ, 1910), and in a short but very important later paper on the classification of the family as a whole (Records Indian Mus. v. pt. iv. 1910, p. 253), Lt.-Col. Alcock has given an entirely new aspect to the system of the Potamonidæ. It is necessary, therefore, to enquire how the Madagascar species stand with reference to the new divisions of the family. Relying mainly, but not exclusively, on the character of the mandibular palp, Alcock has divided the River-Crabs of the Old World (apart from the aberrant Deckeniinæ) into the two subfamilies of Potamoninæ and Gecarcinucinæ. In the former (text-fig. 161, A) the terminal segment of the palp is simple, although it may be thickened and plumose at the base, while in the latter (text-fig. 161, C) it is "deeply cut into two lobes which embrace the incisor process of the mandible." Alcock refers the Madagascar genus *Hydrothelphusa* to the Potamoninæ, but he points out that "the thickening at the base of the terminal joint



of the mandibular palp is more than ordinary prominent." I find that this statement applies not only to *Hydrothelphusa*, but also, and in an even greater degree, to the other Madagascar species that I have examined. In *Hydrothelphusa* the proximal thickening forms a sharply marked ridge; in *Potamon madagascariense* (text-fig. 161, B), *P. goudoti*, and *P. methueni* this ridge overhangs a little as a free lobe. This evidently forms a transition to the bifid palp of the Gecarcinucinae, although it is sufficiently far removed from the typical Gecarcinucine condition as seen in *Parathelphusa tridentata* (text-fig. 161, C), for example, to allow us to refer all the Madagascar species with confidence to the subfamily Potamoninae, with which they also agree in

Text-fig. 161.



Mandibular palp (denuded of setae) of three species of Potamonidae. The lower figures represent the palp as seen from below, the upper figures the terminal segment as seen from in front. A. *Potamon fluviatile*. B. *P. madagascariense*. C. *Parathelphusa tridentata*.

the shape of the male abdomen. It is possible that a similar transitional form of the palp may yet be found in species of Potamoninae from other parts of the world, but it is evident from Alcock's remarks that it does not occur in any of the Indian species; and, in the absence of evidence as to the species of the African and Malaysian Regions, it may be provisionally regarded as suggesting specially close affinity between the species found in Madagascar.

I do not think that much importance attaches to the fact that in all the Madagascar species the palp consists of only two

segments. Alcock found three segments distinct in all the Indian species of *Potamon*, but in his later paper he states that in the Potamoninae the palp has either two or three segments. From the examination of a number of African species I suspect that it will not be possible to distinguish sharply between those species in which the suture-line between the first and second segments is well marked and those in which it is almost or quite obliterated.

As regards the generic affinities of the species here discussed, there is nothing to forbid the conclusion that they are closely interrelated. They have, indeed, been placed in two distinct genera, *Potamon* and *Hydrothelphusa*, and the species of the former might not unreasonably be placed in two subgenera, *Potamon* and *Geothelphusa*, but the groups indicated by these names are probably more convenient than natural. Both Alcock and Miss Rathbun comment on the close resemblance of *Hydrothelphusa* to *Potamon*, and Miss Rathbun specially mentions its affinity with *P. madagascariense*; this affinity becomes even more striking when comparison is made with some specimens of Mr. Methuen's collection which I have described above as representing a form of *P. madagascariense* (Series B). *Potamon goudoti* is considered by Miss Rathbun as forming a link between the subgenera *Potamon* and *Geothelphusa*, and the new species described above as *P. methueni* goes even further in the direction of the latter subgenus. There can, however, be little doubt that *Geothelphusa*, even as restricted by Alcock, has still very slender claims to be regarded as a natural or monophyletic group. A general softening of the asperities of the carapace, such as we frequently see within the limits of undoubted species, has only to be carried a little further to result in the obliteration of the postorbital and epigastric crests; and there is no difficulty in supposing that so short a step may have been taken independently by more than one evolving species. This independence is, in fact, implied by Alcock's transference of certain species of "*Geothelphusa*" to genera of his subfamily Gecarcinucinae, and I think there is some slight evidence of the same thing among those that remain in the Potamoninae. At all events there is no necessity to assume that *P. goudoti* and *P. methueni* are more closely allied to the species of "*Geothelphusa*" found in Africa and Asia than they are to *P. madagascariense*.

*Potamon madagascariense* itself is placed by Miss Rathbun in the group of which *P. edule* (*fluvatile*) is the type. While it certainly resembles the species of this group in the characters of the carapace, it differs a little, as already indicated, in the form of the mandibular palp, and also in some other small characters, such as, for instance, the much broader contact of the basal antennal segment with the front. What the exact value of these differences may be it is at present impossible to say.

### 3. *Geographical Relations of the Madagascar River-Crabs.*

In addition to the species mentioned above, three others have been recorded from Madagascar. The African *Potamon* (*Potamonantes*) *depressum* was recorded by Lenz and Richters, but its occurrence is doubted by Miss Rathbun. *Potamon* (*Potamon*) *pittarellii*, described by Nobili (Boll. Mus. Zool. Torino, xx. No. 507, 1905) since the publication of Miss Rathbun's monograph, appears to be allied to *P. madagascariense*, but is, no doubt, a distinct species. Finally, *Potamon* (*Parathelphusa*) *antongilense*, described by Miss Rathbun, is evidently a remarkable and isolated species, concerning which further information is much to be desired; as far as can be judged from the shape of the male abdomen, it is not a *Parathelphusa* in the sense in which that genus has been restricted by Alcock.

Leaving aside these three species, and considering only those that are represented in the collections now examined, it is evident that the Potamonid fauna of Madagascar bears no close relation to that of Peninsular India, which, as Alcock has shown, belongs entirely to the subfamily Gecarcinucinae. This is important, since geologists seem to be agreed that the connection of Madagascar with India existed only at a time (not later than the early Oligocene) when Peninsular India was separated from the continent of Asia. Of the possible affinities with African species it is perhaps unsafe to speak until the rich Potamonid fauna of Africa shall have been examined as thoroughly as that of India has been by Alcock; but it is worth noting that no typical *Potamon* seems to be known from East Africa; and if, on the one hand, *P. madagascariense* is the most primitive of the Madagascar species, and, on the other, if it is really allied to the group of *P. fluviatile*, then it is hard to guess by what route it can have reached the island. Further than this it does not seem possible at present to go. As I have indicated above, our conceptions of the phylogenetic relationships of the species rest, as yet, on a very narrow basis of morphological fact; and, until that basis is broadened very considerably, the group of River-Crabs, as a whole, appears to me to be a hazardous subject for zoogeographical speculation.

### PART II.—Family PALÆMONIDÆ (River-Prawns).

The Palæmonidæ of Madagascar have already formed the subject of an important memoir by Coutière (Ann. Sci. Nat. Zool. (8) xii. 1900, pp. 249-342, 5 pls.), on which I have relied mainly for the determination of the four species in Mr. Methuen's collection. These are as follows:—

- Palæmon lepidactylus* Hilgendorf.
- „ *dolichodactylus* Hilgendorf.
- „ *ritsemæ* de Man.
- „ *hildebrandti* Hilgendorf.

While all the adult males and a good many of the females in the collection have been referred to one or other of these species, there remain over a number of specimens which either lack the large chelipeds or are clearly immature. It is possible that these may include representatives of some other species, but I have not succeeded in identifying them, and it does not seem that any good purpose would be served by enumerating them here.

The most interesting species in the collection is that which I identify with *Bithynis hildebrandti* of Hilgendorf, which does not appear to have been re-examined since its description in 1897. The series of specimens collected by Mr. Methuen, together with those already in the Museum Collection, show, I think, that this species is not closely related to the Chilian species which is the genotype of *Bithynis*; that the single character which led to its being referred to the genus *Bithynis* is a matter of individual variation; and that, therefore, the species should be removed to the genus *Palæmon*.

*PALEMON (MACROBRACHIUM) LEPIDACTYLUS* Hilgendorf.

*Palæmonlepidactylus* Hilgendorf, Monatsber. Akad. Wiss. Berlin, 1878 (1879), p. 838, pl. iv. figs. 14-16.

*Palæmon (Macrobrachium) lepidactylus* Coutière, Ann. Sci. Nat. Zool. (8) xii. 1900, p. 272, pls. x., xi. figs. 1-13 a.

*Localities.* Ambatonharanana, 7 males (*Methuen*); Rapides de l'Ifofry, 1 male (*Methuen*); Betsileo, 3 males, B.M. 80.27.

In the characters of the rostrum and of the larger cheliped all the specimens fall within the range of variation determined for this species by Coutière. In no case, however, does the form of the smaller cheliped agree with that which he regards as typical. The fingers of this appendage are in all the specimens straight or nearly so, meeting completely or with only a slight gap, and having a scanty provision of bristles on their opposed edges. In these respects the specimens agree much better with Coutière's *P. hilgendorfi*, and suggest that that species should not be regarded as distinct from *P. lepidactylus*.

*PALEMON (PARAPALEMON) DOLICHODACTYLUS* Hilgendorf.

*Palæmon dolichodactylus* Hilgendorf, Monatsber. Akad. Wiss. Berlin, 1878 (1879), p. 840, pl. iv. fig. 18.

*Palæmon dolichodactylus* Coutière, Ann. Sci. Nat. Zool. (8) xii. 1900, p. 283, pl. xi. figs. 18, 19.

*Localities.* Andranolaho and Tongoroby, Onilahy River, 15 males, 3 females (*Methuen*).

The larger males in the collection agree very well with the accounts of this well-marked species given by Hilgendorf and by Coutière. With them are associated some smaller specimens in which the woolly covering of the larger chela is very slightly developed. The rostral formula is  $\frac{13-15}{2-4}$ , with 4-5 of the upper teeth postorbital.

## PALÆMON (EUPALÆMON) RITSEMÆ de Man.

*Palæmon (Eupalæmon) ritsemæ* de Man, Zool. Jahrb., Abth. Syst. ix. 1897, p. 774: op. cit. x. 1898, pl. xxxvii. fig. 70.

*Palæmon ritsemæ* Coutière, Ann. Sci. Nat. Zool. (8) xii. 1900, p. 314, pl. xiii. figs. 32-33 a.

*Localities.* Manambato, streams running into Lake Rasorabé, 3 males, 8 females (*Methuen*); Ivondro, 6 males (*Methuen*); Ambilo, 2 males (*Methuen*); Tamatave, 1 male, B.M. 82.6.

The specimens collected by Mr. Methuen belong, without doubt, to the same species as a specimen in the Museum Collection from Tamatave, determined by Mr. Miers as *P. idæ* Heller. They differ conspicuously from typical specimens of that species, however, in the fact that the surface of the carapace and of the tail-fan is completely smooth or presents only very minute and inconspicuous traces of spinules, while the chelipeds of the second pair are very finely scabrous. Since Nobili has described a smooth or nearly smooth variety of *P. idæ* from New Guinea, and Coutière records a similar example from Madagascar, this character may not be of specific value. The chelipeds of the second pair are shorter, in relation to the body-length, than in Coutière's specimens of *P. idæ*, the longest being only about  $1\frac{1}{2}$  of that length, and most of them being actually shorter. Although the carpus is, except in three instances, longer than the chela, the difference is very much less than is shown by Coutière's measurements in specimens of *P. idæ* of similar size, and the fingers are always much more than half the length of the palm. On the other hand, the rostral formula in nearly all cases falls within the somewhat narrow limits assigned to the variations of this character in *P. idæ*, and the armature of the fingers agrees precisely with Coutière's description.

In all the points mentioned in which these specimens differ from the descriptions of *P. idæ*, they approach Coutière's account of the form which he identifies with *P. ritsemæ* de Man. Our smaller specimens, however, which alone are directly comparable with Coutière's largest, have the second chelipeds more asymmetrical and apparently a good deal stouter, the chela itself, and especially the palm, being relatively a little shorter. The larger specimens have many of the proportions rather different, the greater relative length of the palm in most of them being noteworthy. Finally, in the specimens now examined, the posterior peræopods are, on the whole, stouter than in those previously described in this species, the ratio of length to breadth in the propodus of the fifth pair varying from 25 to 21, while de Man gives the ratio as from 35 to 25 and Coutière as 25.

On the whole, the balance of characters seems to be in favour of regarding our specimens as older individuals of the species to which Coutière's specimens belonged, which he has recorded under the name of *P. ritsemæ*; whether they really belong to de Man's species is, perhaps, a little more doubtful; and I am not at all

confident that they would be found to differ essentially from the smooth variety of *P. idæ*. It may be noted that, in having parts of the surface of the carapace slightly scabrous, some of our specimens agree with *P. sintangensis* de Man, which Coutière regards as a varietal form of *P. ritsemæ*.

The following table gives (in millimetres) the more important measurements of all the specimens that have one or both chelipeds of the second pair preserved. The "total length" of the body and also the "total length" of the chelipeds of the second pair are only approximate, on account of the impossibility of straightening the specimens without injury. In an ovigerous female the eggs measured  $5 \times 4$  mm.

Measurements of *Palemon ritsemæ*.

Locality, &c.	Sex	Total length.	Rostral formula.	Chelipeds of second pair.					
				Total length.	Merus.	Carpus.	Chela.	Palm.	Fingers.
Ivondro, Methuen, No. 96 ...	♂	116	?	110	20	37.5	36	21	15
" 95 ...	♂	105	$\frac{2+9}{4}$	$\left\{ \begin{array}{l} 123 \\ 93 \end{array} \right.$	$\left\{ \begin{array}{l} 20.5 \\ 18 \end{array} \right.$	$\left\{ \begin{array}{l} 43 \\ 29.5 \end{array} \right.$	$\left\{ \begin{array}{l} 38.5 \\ 27 \end{array} \right.$	$\left\{ \begin{array}{l} 24.5 \\ 17.5 \end{array} \right.$	$\left\{ \begin{array}{l} 14 \\ 9.5 \end{array} \right.$
" 97 ...	♂	103	$\frac{2+9}{4}$	88	14	27.5	26	16	10
Manambato, Methuen, No. 42 ...	♂	98	$\frac{2+8}{4}$	74	12	22	23.5	13.5	10
Ivondro, Methuen, No. 99 ...	♂	95	$\frac{2+8}{4}$	$\left\{ \begin{array}{l} 93 \\ 73 \end{array} \right.$	$\left\{ \begin{array}{l} 16 \\ 14 \end{array} \right.$	$\left\{ \begin{array}{l} 31 \\ 24 \end{array} \right.$	$\left\{ \begin{array}{l} 29 \\ 26 \end{array} \right.$	$\left\{ \begin{array}{l} 17 \\ 14.5 \end{array} \right.$	$\left\{ \begin{array}{l} 12 \\ 11.5 \end{array} \right.$
Manambato, Methuen, No. 46 ...	♀	92	$\frac{3+8}{4}$	?	10	16.5	16.5	8.5	8
Tamatave, B.M. 82.6 ...	♂	90	$\frac{2+7}{3}$	90	18	35	33.5	20	13.5
Manambato, Methuen, No. 47 ...	♂	80	$\frac{2+8}{3}$	56.5	10	17.5	17	9.5	7.5
" 45 ...	♀	75	?	?	9	15.5	15	8.5	6.5

*PALEMON HILDEBRANDTI* Hilgendorf. (Plate XCII.)

*Bithynis* (?) *hildebrandti* Hilgendorf, Sitz.-Ber. Ges. Naturf. Freunde Berlin, 1893, p. 244; Coutière, Ann. Sci. Nat. Zool. (8) xii. 1900, pp. 250, 256, 259; Ortmann, Bronn's Thierreich, Crustacea, ii. 1901, p. 1292; Ortmann, Proc. Amer. Phil. Soc. Philadelphia, xli. 1902, p. 274.

The material which I have examined consists of eleven specimens, from three localities, in the British Museum (Nat. Hist.) Collection and nineteen specimens from one locality in Mr. Methuen's collection. The Museum specimens (Pl. XCII. fig. 1) agree with Hilgendorf's description of this species, except in one or two small details to be mentioned below. Mr. Methuen's specimens were at first regarded as representing a probably new species of *Palæmon*, since they possess a well-developed hepatic spine on the carapace (Pl. XCII. fig. 6). Closer examination showed, however, that they differed in no other respect from the Museum specimens, and their specific identity was finally proved by the discovery, among Mr. Methuen's specimens, of one which has no trace of a hepatic spine on one side of the carapace, while on the other side its place is indicated by a small and inconspicuous tubercle.

The following description applies to all the specimens examined.

The sides of the carapace and the abdominal somites are rather coarsely punctate. The rostrum is more or less straight, with the dorsal edge moderately arched, of varying length but always shorter than the antennal scale, and often shorter than the antennular peduncle; of the dorsal teeth, one is postorbital.

The tip of the telson (Pl. XCII. figs. 4 & 5) is rather broadly rounded, sometimes, but not always, with a minute median point; the inner lateral spines are much longer than the outer. Between the inner spines is a fringe of sixteen plumose hairs.

The third maxilliped does not reach the tip of the antennal scale. The chelipeds of the first pair extend beyond the scale by a little more than the chela.

The chelipeds of the second pair (Pl. XCII. fig. 2) are similar, smooth, with fine scattered setules, and may extend beyond the antennal scale by the length of the chela and carpus. The carpus is equal to the merus, widened distally; the chela slightly compressed (5:6), a little wider than distal end of carpus; palm longer than carpus and equal to fingers; fingers with a sharp cutting-edge for the greater part of their length, with two small teeth near the base of the dactylus, and one, with an indistinct second, on the immovable finger (Pl. XCII. fig. 3).

Posterior legs moderately stout, propodus of last pair about twelve times as long as wide and about four times as long as the dactylus.

The females are ovigerous from a length of about 38 mm. upwards. The eggs measure approximately  $2 \times 1.4$  mm.

It will be observed, from the table of measurements given below, that the females are much more numerous than the males in the collections examined and also that they considerably exceed them in size; both conditions appear to be uncommon among the species of *Palæmon*, but they are found also in *P. moorei* of Lake Tanganyika.

Hilgendorf described the mandibular palps as consisting of only two segments. In all the specimens which I have dissected the usual three segments are distinct. Hilgendorf also attributes three teeth to the dactylus of the second chelipeds and states that

the carpus "ragt nur ein wenig unter die Antennenschuppe nach vorn," while in our specimen the dactylus bears only two teeth and the carpus may extend beyond the tip of the antennal scale. In all other respects, however, Hilgendorf's description applies so well to our specimens that their specific identity can hardly be in doubt.

The existence of an affinity between this species and the *Bithynis gaudichaudii* of Chile and Peru, asserted only in a hesitating manner by Hilgendorf, is fully accepted by Coutière, but denied by Ortmann, who considers that the resemblance does not extend beyond a single character (the lack of a hepatic spine) which may easily be supposed to have arisen by convergence. Ortmann's view is strongly supported by the variability of this character in the present series of specimens. I have examined the appendages of both species for other evidence of affinity between them, and have failed to find it. The branchial system and the mouth-parts of both are very similar to those of several species of *Palæmon* with which I have compared them. Only in one point do the mouth-parts of *B. hildebrandti* present anything unusual, and that is the reduced size of the epipodite of the first maxillipeds, but this constitutes no resemblance to *B. gaudichaudii*, in which the epipodite is quite as large as in the species of *Palæmon* examined. On the other hand, the differences in general aspect between the two species are considerable; *B. hildebrandti* has the chelipeds hardly differing in the two sexes, slender, symmetrical, smooth, with the carpus equal to the merus, and the fingers armed with only a few small teeth near the base; *B. gaudichaudii* is a very much larger species, with the chelipeds very stout, much more strongly developed in the male than in the female, very unequal on the two sides of the body, beset with spiny tubercles, with the carpus shorter than the merus, and the fingers of the larger chela toothed for half their length or more. If it be advisable to maintain the genus *Bithynis* (which seems to me doubtful) it must be for the South American species alone, and *B. hildebrandti* must be transferred to the genus *Palæmon*.

The variability of the hepatic spine in this species recalls the cases of "mutation" recently described by Bouvier in certain *Atyidæ*. It resembles these cases in its discontinuity, only one individual out of those examined being in any way intermediate between the two forms; and it further resembles some of them at least in the fact that it is geographically limited, for the specimens of the two forms come from different localities. Both of these points, however, require to be tested by further collecting. It differs from Bouvier's cases in that it concerns only a single character, and one which, were it not for its constancy in other *Palæmonidæ*, might be regarded as of trivial importance.

The large size of the eggs may be taken to indicate an abbreviation or suppression of the larval development, and this is likely to be associated, as it is in some other *Palæmonidæ*, with



an exclusively fresh-water habitat and a restricted area of distribution; it may be not without significance therefore, that, of the species of *Palæmonidæ* in the present collection, *P. hildebrandti* is the only one that does not occur outside the island of Madagascar.

Measurements of *Palæmon hildebrandti*.

Locality, &c.	Sex.	Total length.	Rostral formula.	Hepatic spine.	Chelipeds of second pair.				
					Merus.	Carpus.	Chela.	Palm.	Fingers.
Ambatonharanana, Methuen .....	♀	46	$\frac{1+6}{1}$	+	6.0	6.5	15.5	7.75	7.75
" .....	♀	45	$\frac{1+6}{0}$	+	.....	.....	.....	.....	.....
" .....	♀	45	$\frac{1+5}{0}$	+	5.3	5.5	14.0	7.0	7.0
" .....	♀	45	$\frac{1+5}{2}$	+	5.5	5.2	14.0	7.5	6.5
" .....	♀	44	$\frac{1+5}{0}$	+	5.5	5.5	14.0	7.0	7.0
" .....	♀	43	$\frac{1+6}{1}$	+	.....	.....	.....	.....	.....
" .....	♀	42	$\frac{1+5}{2}$	+	5.5	5.5	14.0	7.5	6.5
" .....	♀	40	$\frac{1+6}{0}$	+	5.5	5.5	14.0	7.0	7.0
" .....	♀	40	$\frac{1+6}{2}$	+	4.8	5.0	9.3	5.0	4.3
" .....	♀	39	$\frac{1+6}{1}$	+	5.2	5.5	14.0	7.5	6.5
" .....	♀	38	$\frac{1+7}{2}$	+	4.7	4.6	11.0	6.0	5.0
" .....	♀	38	$\frac{1+5}{1}$	+	4.0	4.0	10.0	5.2	4.8
" .....	♀	36	$\frac{1+7}{2}$	+	4.2	4.5	10.4	5.2	5.2
" .....	♀	36	$\frac{1+6}{2}$	+	4.5	4.5	9.5	5.0	4.5
" .....	♂	35	$\frac{1+5}{1}$	+	.....	.....	.....	.....	.....
" .....	♂	32	$\frac{1+7}{1}$	+	3.7	3.9	8.6	4.5	4.1
" .....	♂	32	$\frac{1+5}{1}$	+	4.0	4.0	9.3	5.0	4.3
" .....	♂	32	$\frac{1+6}{1}$	0	4.2	4.3	9.1	4.8	4.3
" .....	♂	28	$\frac{0+6}{0}$	+	.....	.....	.....	.....	.....

Measurements of *Palæmon hildebrandti* (continued).

Locality, &c.	Sex.	Total length.	Rostral formula.	Hepatic spine.	Chelipeds of second pair.				
					Merus.	Carpus.	Chela.	Palm.	Fingers.
Betsileo, B.M. 82.6.	♀	50	$\frac{1+5}{3}$	0	$\begin{cases} 6.0 \\ 6.0 \end{cases}$	$\begin{cases} 6.0 \\ 6.0 \end{cases}$	$\begin{cases} 13.0 \\ 14.5 \end{cases}$	$\begin{cases} 7.0 \\ 8.0 \end{cases}$	$\begin{cases} 6.0 \\ 6.5 \end{cases}$
" " "	♀	48	$\frac{1+6}{2}$	0	.....	.....	.....	.....	.....
" " "	♀	46	$\frac{1+7}{2}$	0	$\begin{cases} 5.7 \\ 5.7 \end{cases}$	$\begin{cases} 5.7 \\ 5.7 \end{cases}$	$\begin{cases} 13.0 \\ 12.2 \end{cases}$	$\begin{cases} 7.0 \\ 6.5 \end{cases}$	$\begin{cases} 6.0 \\ 5.7 \end{cases}$
" " "	♀	46	$\frac{1+6}{2}$	0	$\begin{cases} 6.0 \\ 6.0 \end{cases}$	$\begin{cases} 6.0 \\ 5.5 \end{cases}$	$\begin{cases} 12.2 \\ 12.0 \end{cases}$	$\begin{cases} 6.7 \\ 6.5 \end{cases}$	$\begin{cases} 5.5 \\ 5.5 \end{cases}$
" " "	♀	46	$\frac{1+7}{3}$	0	6.0	6.0	12.0	7.0	5.0
" " "	♂	43	$\frac{1+8}{3}$	0	6.0	6.0	13.5	7.5	6.0
" " "	♀	38	$\frac{1+7}{2}$	0	$\begin{cases} 4.5 \\ 4.5 \end{cases}$	$\begin{cases} 4.5 \\ 4.5 \end{cases}$	$\begin{cases} 8.9 \\ 8.9 \end{cases}$	$\begin{cases} 4.7 \\ 4.7 \end{cases}$	$\begin{cases} 4.2 \\ 4.2 \end{cases}$
Madagascar, B.M. 79.20	♀	52	$\frac{1+7}{4}$	0	.....	.....	.....	.....	.....
" " "	♀	?	$\frac{1+5}{2}$	0	6.0	6.0	14.0	8.0	6.0
East Imerina, B.M. 92.7.4.6-7	♀	37	$\frac{1+6}{1}$	0	.....	.....	.....	.....	.....
" " "	♀	37	$\frac{1+6}{2}$	0	.....	.....	.....	.....	.....

## EXPLANATION OF THE PLATES.

## PLATE XCI.

*Potamon methueni*, sp. n.

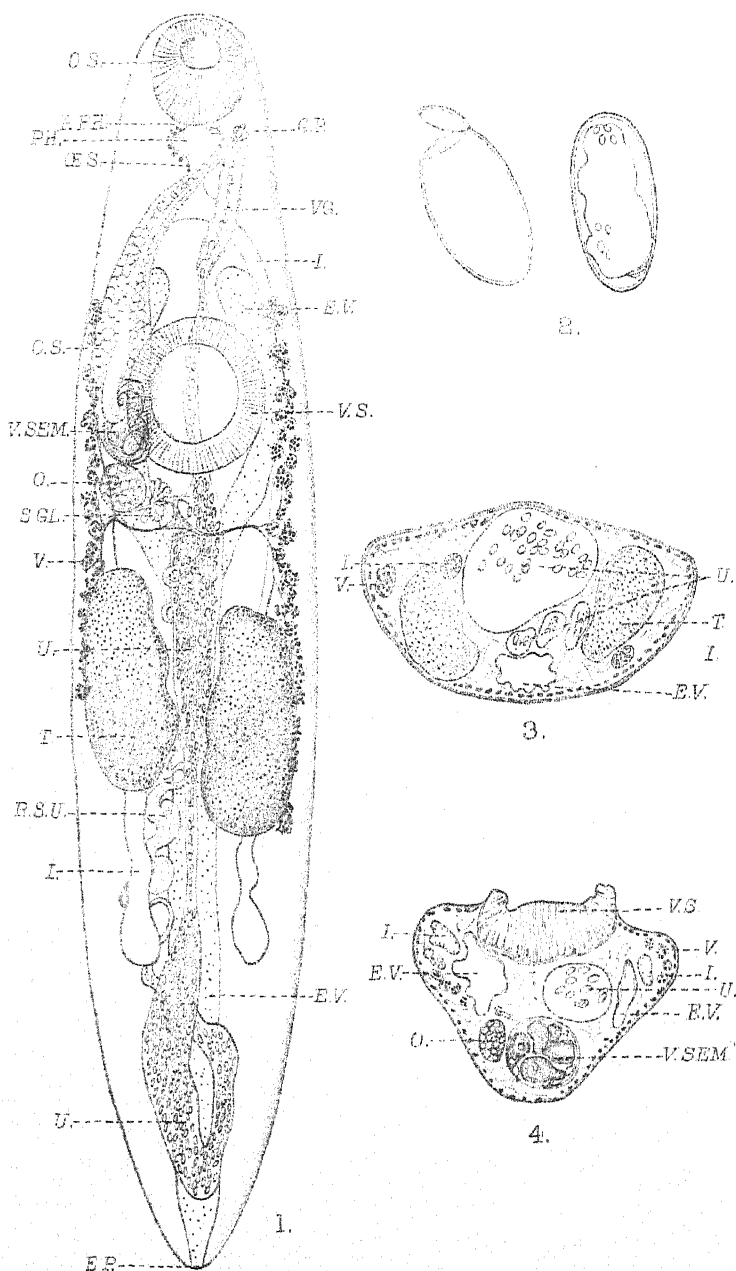
- Fig. 1. Male. Holotype. Natural size.  
 2. " " Hand of larger cheliped.  $\times 1\frac{1}{2}$ .  
 3. " " Abdomen.  $\times 1\frac{1}{2}$ .  
 4. " " Third maxilliped.  $\times 2\frac{1}{2}$ .

## PLATE XCII.

*Palæmon hildebrandti*.

- Fig. 1. Typical form, ovigerous female.  $\times 2\frac{1}{2}$ .  
 2. " " Cheliped.  $\times 5$ .  
 3. " " base of fingers.  $\times 10$ .  
 4. " " Telson.  $\times 10$ .  
 5. " " Tip of telson.  $\times 15$ .  
 6. Form with hepatic spine. Carapace.  $\times 2\frac{1}{2}$ .





M.L. del.

Huth, Lith. London.

LECHRIORCHIS INERMIS.

53. A New Trematode of the Genus *Lechriorchis* from the Dark Green Snake (*Zamenis gemonensis*). By MARIE V. LEBOUR, M.Sc., Assistant Lecturer and Demonstrator in Zoology, Leeds University\*.

[Received September 20, 1913: Read November 25, 1913.]

(Plate XCIII.†)

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Systematic: <i>Lechriorchis inermis</i> , sp. n., from the body-cavity of <i>Zamenis gemonensis</i> .....	933-936

On June 10th, 1913, a specimen of a Dark Green Snake (*Zamenis gemonensis*), from Southern Europe, died in the Zoological Society's Gardens, and loose in the body-cavity were a large number of Trematodes which were sent to me for identification. These prove to be a new species of *Lechriorchis* Stafford closely related to *L. validus* Nicoll (1911). The habitat is interesting as all the Trematodes of the group which includes *Lechriorchis* whose habitat is known, occur in the air-passages, pharynx, or anterior part of the œsophagus of their hosts. This appears to be the first time that one of this group has been found occupying the body-cavity.

An interesting feature in the new species is the absence of spines on the body. The cuticle is quite smooth, unlike any of the other members of the genus. However, in some specimens spines can be seen below the surface of the cuticle, but not reaching to the outside, which seems to indicate a gradual disappearance of spines owing to the worm living in the body-cavity of its host, and therefore being in no danger of getting swept away as is the case in open passages. In all other ways it agrees closely with the other members of the genus.

On account of the absence of spines I propose for this new species the name *Lechriorchis inermis*.

#### LECHRIORCHIS INERMIS, sp. n. (Pl. XCIII.)

Length of body 5-10 mm. Oral sucker 0.40-0.60 mm. Ventral sucker 0.60-0.92 mm. Average ratio of oral to ventral sucker 2:3. Prepharynx small, œsophagus the same length as pharynx. Intestinal cæca reaching a good way beyond testes.

\* Communicated by the SECRETARY.

† For explanation of the Plate see p. 936.

Testes behind centre of body, right in front of left. Cirrus-sac reaching to posterior margin of ventral sucker. Ovary on right side behind or slightly overlapping ventral sucker. Yolk-glands reaching from just in front of the level of the anterior margin of ventral sucker to centre of testes or behind them. Receptaculum seminis uterinum present on right side of body behind right testis.

The body (fig. 1) is convex dorsally and nearly flat ventrally, both suckers being conspicuous and the cirrus usually protruding from the genital pore. The length of mature worms varies from 5 to 10 mm., the last-named being in the case of a specially well extended specimen examined under pressure. Unfortunately, this large specimen was damaged before being fixed. One immature specimen occurred measuring 4.4 mm. in length which contained a few eggs and had a very short uterus. In breadth the worms measured from 1.2 mm. to 1.9 mm., the greatest breadth being in the region of the ventral sucker. The average length is about 5.5 mm., breadth 1.4 mm.

A good deal of interesting variation occurred in the arrangement of the organs. The suckers vary but little, the ratio of the oral and ventral suckers being almost exactly 2 : 3. Both are circular in outline with circular apertures. The aperture of the oral sucker measures about 0.20 mm. across; the aperture of the ventral sucker is more than half the width of the sucker and very regular and conspicuous. The usual position of the ventral sucker is with its centre almost exactly at the anterior third of the body. It may, however, be a little further back. In the young specimen it is much nearer the centre of the body, a fact to be expected as the hind portion of the body always increases to a much greater extent than the fore part.

The prepharynx is exceedingly short but quite distinct; the pharynx is broad and muscular, the breadth slightly greater than the length (length 0.20 mm.); the œsophagus is about the same length as the pharynx. Surrounding the pharynx are large glandular cells which are continued for a short distance down the œsophagus. Pharyngeal glands are mentioned by Stafford in *L. primus* (1905). The intestinal cæca vary in thickness in different parts and reach usually about 0.60 mm. beyond the testes; beginning near the centre of the body, they gradually become more lateral and slightly ventral in position until they reach the testes, when they become quite irregular and may be both dorsal to the testes or one ventral and one dorsal (fig. 3); and one may be longer than the other, in one case quite twice as much extending beyond the left testis as the right. The usual length beyond the testes is 0.60 mm. Sometimes the cæca bend inwards so as to be completely internal to the testes. The ends are swollen and very much broader in the posterior than in the anterior part.

The excretory vesicle is large and opens at the extreme posterior

end, where it is surrounded by large deeply staining cells; just in front of the opening the vesicle is much folded, giving it the appearance of having been "puckered in" before the narrow opening. In front of this pleating it widens out as a large tube running dorsal to and parallel with the ascending limb of the uterus; in front of the testes and behind the ovary it forks, each limb reaching far forward beyond the ventral sucker to about midway between the ventral sucker and pharynx.

The testes are oval bodies more or less lobed on their inner margins, usually lying obliquely with the right testis in front of the left; the usual situation is for the right to be about 0.15 mm. in front of the left, but they may be almost on a level, and in two cases the left testis was in front of the right. Curiously enough, these variations occurred in the small immature worm and in the largest specimen. It is just possible that we may have to do here with a different species. In a specimen 5.2 mm. in length the testes measured, right 0.90 mm.  $\times$  0.44 mm., left 0.84 mm.  $\times$  0.44 mm., the greater axis lying longitudinally. On the inner margin there are two or three lobes. The cirrus-sac is long and reaches almost to the posterior level of the ventral sucker. Sometimes it reaches the extreme posterior end, and in two cases (again the immature worm and the largest) it was much shorter and only reached a short way behind the anterior margin of the ventral sucker; in this respect being much nearer *L. validus* Nicoll. The vesicula seminalis is much convoluted and occupies the posterior third of the cirrus-sac, the ductus ejaculatorius being surrounded by an enormous mass of prostatic cells and ending in a short protrusible cirrus often to be seen exerted from the genital pore. The male opening is on the right side of the genital pore, which is situated on a level with the centre of the pharynx and midway between it and the lateral margin of the body-wall. The ovary is almost round, and lies dorsally on the right side of the body immediately in front of the right testis. It overlaps the ventral sucker for about a third of its diameter; its position varies however, and in some cases it may be rather more than this and in others not so much. The portion of the ovary that overlaps the cirrus-pouch is on its right side. The oviduct receives a large shell-gland, gives off a Laurer's canal, and receives the vitellarian duct, then runs down as the uterus in many coils to nearly the posterior end of the body, when it doubles back as a much broader tube, runs forward gradually straightening and narrowing and passes the ventral sucker dorsally. In the course of the descending portion behind the right testis is a receptaculum seminis uterinum. When the uterus reaches the level of the anterior ends of the excretory vesicle its walls form a vagina with a thick cuticular lining, and surrounded by a layer of deeply staining large cells which accompany it for the whole of its course until it opens on the left side of the genital pore. The eggs are very numerous and of a deep brown colour when old, the young eggs being much paler.

The cap is not very conspicuous until the egg is open. The eggs (fig. 2) measure  $\cdot 033$  mm.— $\cdot 036$  mm.  $\times$   $\cdot 021$  mm.— $\cdot 023$  mm. The vitellaria are variable in length, but never reach beyond an extremely short distance in front of the ventral sucker,  $0\cdot 02$  mm. is quite the furthest they ever reach and usually it is not so much. Posteriorly they reach to about the middle of the testes, but are extremely variable in this region, and the left may reach to behind the left testes and the right hardly reach to the anterior portion of the right, or both may reach to the level of the middle of the testes. The vitellarian follicles are in small groups lying laterally to the outside of the intestinal caeca; small ducts from them unite in a transverse duct each side lying just behind the ovary, and these unite in a small reservoir in the centre of the body which gives off the vitellarian duct to the oviduct.

*Lechriorchis validus* Nicoll is undoubtedly the most nearly related to the present species. *L. inermis* differs from it chiefly in its much smaller eggs and position of the vitellaria. The position of the testes (right in front of left instead of the reverse) and of the vesicula seminalis being rather more variable, do not seem to be such important specific characters.

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- NICOLL, W. (1911).—On Three New Trematodes from Reptiles. Proceedings of the Zoological Society of London, pp. 677–681.  
 STAFFORD, J. (1905).—Trematodes from Canadian Vertebrates. Zoologischer Anzeiger, xxviii. p. 691.

#### EXPLANATION OF PLATE XCIII.

##### *Lechriorchis inermis*, sp. n.

The following letters apply to all the figures.

C.S. Cirrus-sac.	R.S.U. Receptaculum seminis
E.P. Excretory pore.	uterinum.
E.V. Excretory vesicle.	S.GL. Shell-gland.
G.P. Genital pore.	T. Testis.
I. Intestine.	U. Uterus.
O. Ovary.	V. Vitellaria.
ŒS. Œsophagus.	VG. Vagina.
O.S. Oral sucker.	V.S. Ventral sucker.
PH. Pharynx.	V.SEM. Vesicula seminalis.
P.PH. Prepharynx.	

Fig. 1. Ventral view. Length  $5\cdot 4$  mm.

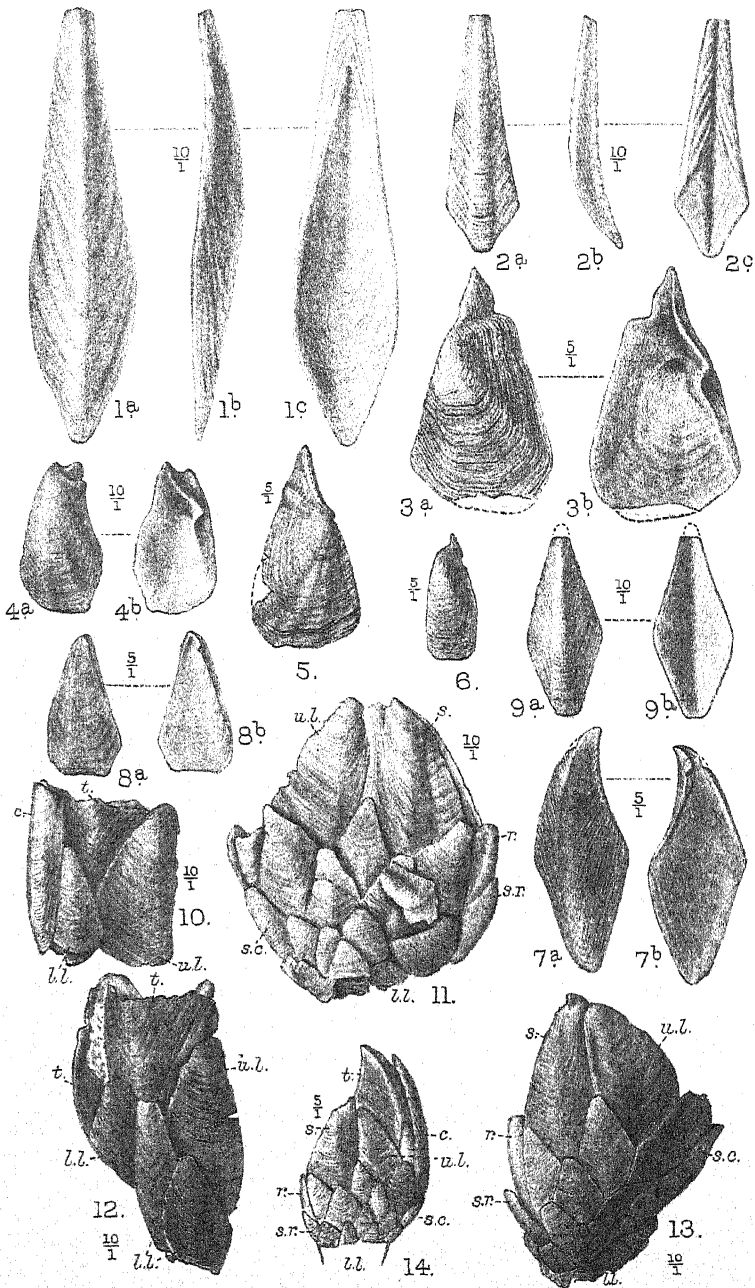
2. Eggs, length  $\cdot 033$  mm.

3. Transverse section through unpaired portion of excretory vesicle and testes, showing intestinal caeca irregularly placed.

4. Transverse section through ventral sucker.





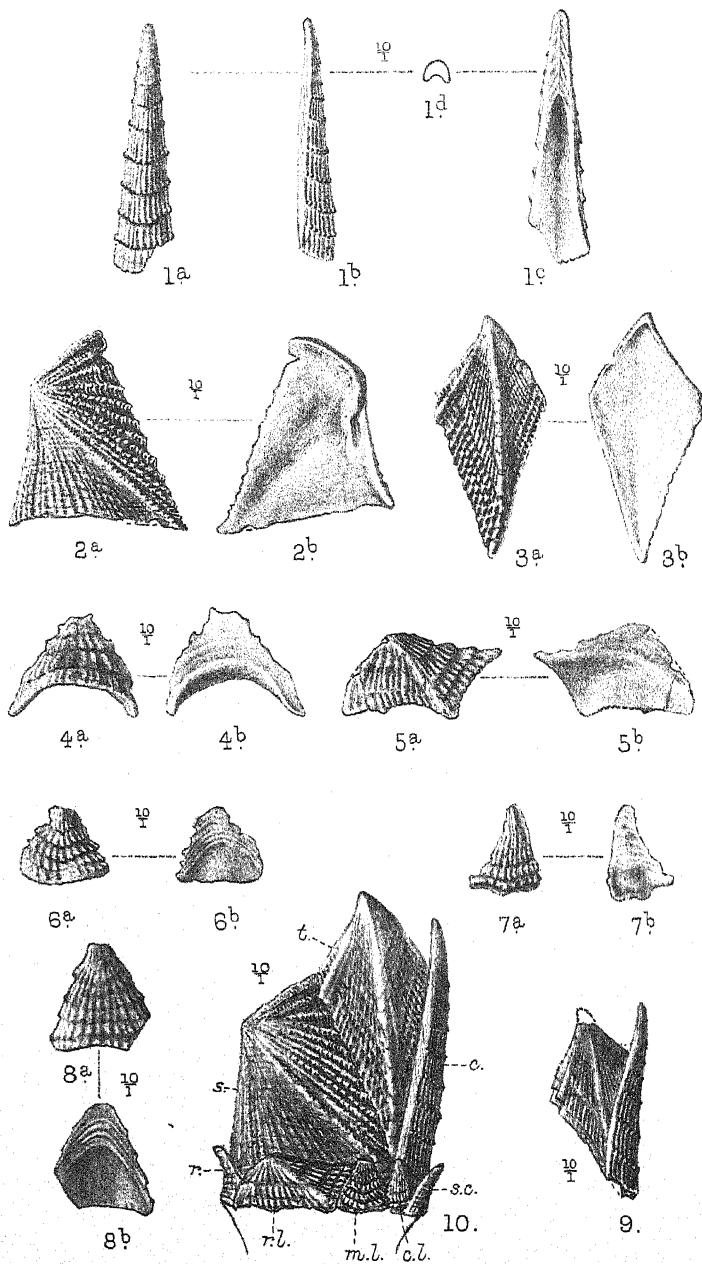


A.H.Searle del. et lith.

Huth imp.

ZEUGMATOLEPAS MOCKLERI gen. et sp.n.





A.H.Searle del et lith.

Huth imp.

CALANTICA (TITANOLEPAS) TUBERCULATA, Darwin sp.

54. Cirripedes from the Cenomanian Chalk Marl of Cambridge. By THOMAS H. WITHERS, F.G.S.\*

[Received September 25, 1913 : Read November 25, 1913.]

(Plates XCIV. & XCV.†)

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Through the industry of the late Mr. F. Mockler, I have been enabled to examine a large series of Cirripede remains which he obtained from the Cenomanian Chalk Marl in the neighbourhood of Cambridge. By far the greater number can be referred to two species, which add materially to our knowledge of the phylogeny of the pedunculate Cirripedes.

One, *Zeugmatolepas mockleri*, gen. et sp. n., is represented by two nearly complete capitula and portions of nine others, as well as a large number of isolated valves. It is interesting from the fact that, while it agrees with the species of *Pollicipes* in the number of valves of the capitulum, it differs not only in the more specialized form of scutum, but also in the size and position of the upper latera, which are nearly as large as the scuta, and have become elevated to occupy the whole of the space between the scuta and terga. This form certainly serves more than any other to connect the genus *Pollicipes* to *Scalpellum*, and, together with *S. (?) cretæ* Steenstrup sp., from the Upper Senonian of Denmark, is now included in the new genus *Zeugmatolepas*.

The second species, *Scalpellum tuberculatum* Darwin, is represented by a large number of separated valves, including several not previously known. These enable us not only to reconstruct the capitulum, but also to show that the species must be referred to the genus *Calantica* Gray. Representatives of that genus are now found living, and the geologically oldest species of its subgenus *Scillælepas*, to which *Scalpellum tuberculatum* comes nearest, occurs in the Miocene of Italy. The recent and Tertiary species have the umbones of all the valves apical, so that it is surprising to find in the Cretaceous representative,

\* Communicated by Dr. W. T. CALMAN, F.Z.S.

† For explanation of the Plates see p. 948.

*S. tuberculatum*, a more specialized form of scutum, the umbo being subcentral. On account of its higher evolutionary development, *S. tuberculatum* is placed in a new subgenus of *Calantica*, namely *Titanolepas*, and it is here suggested that this form may represent an offshoot from the ancestral *Scillalepas* line, and may eventually have given rise to the genus *Oxynaspis*.

Both species are remarkable in having an advanced form of scutum in which the umbo is subcentral, and, together with a small undescribed species of which only the carina is known, constitute the oldest known examples of this specialized type of valve. It is quite evident that *Zeugmatolepas mockleri* and *Titanolepas tuberculata* are derived from either the genus *Pollicipes* or from a *Pollicipes*-like ancestor, and both have evolved the same type of scutum. These forms seem to show that the transition of the umbo in the scutum from an apical to a subcentral position, has occurred independently in unrelated forms belonging to distinct lines of development, and recent work leads me to believe that this is equally true also of the carina in the more advanced forms of *Scalpellum* (*sensu lato*). In *T. tuberculata* the position of the umbo in the scutum is constant; but in *Z. mockleri* it changes apparently according to age, although some individuals seem to be more advanced in this respect. It may be, therefore, that in the scutum of *Z. mockleri* the subcentral umbo was quite a recent development.

The two species must have been comparatively common in the Chalk sea, for of *Zeugmatolepas mockleri* we have remains of at least 100 capitula, and of *Titanolepas tuberculata* more than 30.

#### FAMILY POLLICIPEDIDÆ.

##### ZEUGMATOLEPAS\*, gen. nov.

Capitulum longer than broad, comprising at least 34 valves, composed of scuta, terga, upper latera, and carina, and three or more whorls of subtriangular lower latera, with a rostrum, subrostrum, and subcarina; upper latera almost as large as the scuta, occupying the whole of the space between the scuta and terga, the apices of the upper latera contiguous with those of the scuta; umbo of scuta subcentral, and of the remaining valves apical.

*Genotype*.—*Zeugmatolepas mockleri*.

*ZEUGMATOLEPAS MOCKLERI*, sp. n. (Plate XCIV. figs. 1-14.)

*Diagnosis*.—Valves thin and generally smooth. Carina narrow, usually with a strong, median, rounded keel, not divided off into parietes and intraparietes, basal margin acutely angular. Scutum subtriangular to trapezoidal in shape, with the umbo varying in position from just below the apex to about one-third the length of the valve from the apex; there is in most scuta a deep trough

\* *Zeugma* = a connecting link.

above the umbo extending almost parallel to the upper occludent margin; apical portion usually constricted and acute; basilateral angle shortly and obliquely truncated. Tergum subrhomboidal, with its upper half curved towards the scuta; basal angle sometimes acute, but more often shortly and obliquely truncated.

*Material*.—Two almost complete capitula and nine portions of others. All of these appear to be immature, and there is also a large series of isolated valves.

*Holotype*.—The nearly complete capitulum, I. 15830 (Pl. XCIV. fig. 11).

*Distribution*.—Cambridge Greensand: Cambridge; Cenomanian, Chalk Marl: near Cambridge, and Birham, Kent; Cenomanian, *A. plena*-marls: Oxted, Surrey, and Wantage, Berkshire; [?Cenomanian], Chalk detritus: Charing, Kent.

*Measurements*.—The two nearly complete capitula (Pl. XCIV. figs. 11, 13) each measure 4 mm. from the apex of the scutum to the base of the lowest whorl of latera, and the uncrushed capitulum (Pl. XCIV. fig. 11) measures 4.2 mm. in breadth. Both are immature examples. Among the detached valves the largest examples of the upper series measure respectively:—

Carina, I. 15820. Length (valve slightly broken at apex) 5.9 mm.; breadth 1.7 mm.

Scutum, I. 15822. Length (from apex to lowest point of basal margin) 6.4 mm.; breadth 4.5 mm.

Tergum, I. 15833. Length 7.6 mm.; breadth 3.4 mm.

Upper latus, I. 15834. Length 4.5 mm.; breadth 3.2 mm.

There are, however, several fragments which show that these valves attained somewhat larger dimensions. A comparison of these with the proportions of the valves, as shown in the nearly complete capitulum, seems to show that the capitulum of the species reached a length of at least 15 mm.

*Description of valves*.—Valves thin, smooth, or ornamented with excessively fine ridges radiating from their umbones.

*Carina* (Pl. XCIV. figs. 1, 2) narrow, widening gradually downwards from the apex to the basal margin, either slightly bowed inwards, straight, or bowed outwards, not divided off into parietes and intraparietes; basal margin acutely angular; tectum slightly to moderately convex transversely; in some carinae there is a strong, rounded, median, longitudinal keel, nearly as wide as the portion of the valve on either side, but in some specimens it is less strongly marked and in others barely perceptible. Inner surface somewhat thickened near the apex and marked with oblique growth-lines; the extent of the surface thus thickened varies, and at the most is one-third of the length of the valve; the valve therefore projected freely to a variable extent.

*Scutum* (Pl. XCIV. figs. 3-6) varying in shape from subtriangular to trapezoidal, moderately convex transversely, the surface of the valve sloping more steeply from the umbo to the lateral margin; umbo situated just below the apex in young specimens, and in mature examples usually occupying a position

about one-third the extent of the valve from the apex; above the umbo the valve is usually produced abruptly into an acute angle; lateral margin longer than the basal margin, almost straight in its lower part and usually sharply bent inwards and upwards above a line with the umbo; basal margin indistinctly marked off into three almost equal parts, the two outer parts being obliquely inclined towards the apex; lower occludent margin slightly convex, about the length of the basal margin; upper occludent margin about half the length of the lower occludent margin, sometimes nearly in line with it, but more often abruptly bent from the umbo towards the lateral margin, and in some cases almost in line with the umbo and nearly at right angles to the lower occludent margin. Almost all the specimens have a strong ridge extending from the umbo to a point just above it on the lateral margin, and above this ridge the narrow portion of the valve is sharply bent downwards and upwards, and forms a deep trough which is bounded by the raised upper occludent margin; three further ridges, not to be seen in some specimens, extend from the umbo to the basal margin, one to the basilateral angle, a second to one-third of the distance from the rostral angle, and a third to midway between the two. On the inner surface there is a deep pit for the adductor scutorum; the inner occludent margin is much thickened, and above the umbo a portion of the valve is bent downwards at right angles to the outer surface in some specimens, and in others it is sharply bent inwards; when the occludent margin is almost in line with the umbo, this downwardly and inwardly bent portion of the valve almost entirely overhangs the pit for the adductor scutorum, and forms a roof to the upper part of the inner surface.

*Tergum* (Pl. XCIV. fig. 7) subrhomboidal, slightly convex transversely, with a feebly marked curved ridge extending from the apex to the basal angle at about one-fifth the width of the valve from the carinal margin, and from this ridge the valve slopes steeply to the carinal margin; upper half of valve curled towards the scuta, and in most valves away from the opposing tergum; apex acute; basal angle sometimes acute, and sometimes slightly and obliquely truncated; carinal margin convex when continuous, but when formed of two almost equal portions, as is usually the case, the upper margin is convex and the lower margin almost straight; scutal or lateral margin straight, almost equal in length to the concave occludent margin, which has a slightly raised border; the shape of the upper carinal and occludent margins is influenced by the extent to which the upper half of the valve is curved towards the scuta, a character which is very variable. Along the occludent margin, especially in those examples conspicuously bowed away from the opposing tergum, a portion of the valve is bent downwards and sharply inwards to form an obtusely angular ledge on the inside of the valve; this ledge, as well as that formed on the inner occludent margin of the scutum, was no doubt for the protection of the animal's body,



for these ledges would serve to fill up the hiatus made through the upper portions of the scuta and terga being bowed away from each other. In some of the terga from the Chalk Marl of Cambridge and Burham, the adoceludent portion of the valve is not bent downwards and inwards to form a ledge on the inner surface, but extends outwards to form a second raised ridge almost parallel with the raised ocludent margin. The terga from the *B. plena*-marls have this outer ridge finely denticulated on its margin.

*Upper latus* (Pl. XCIV. fig. 8) subtriangular, slightly curved towards the scuta, almost flat; umbo slightly projecting; at the scutal margin a narrow slip of the valve is bent downwards, and during the thickening and growth of the valve a slight ledge has been formed which has a tendency to project beyond the umbo; tergal margin slightly convex; scutal margin slightly concave, and about the same length as the tergal margin; basal margin marked off into three almost equal lines, and to the angles thus made two feebly marked ridges extend from the umbo.

*Rostrum* (Pl. XCIV. fig. 9) diamond-shape, bowed inwards; a strong rounded keel extends from the apex, widens gradually to the basal angle, and the portion of the valve on each side slopes steeply towards the lateral margins; apical portion acute; basal portion rather less acute than the apical portion, with the basal angle slightly rounded. The inside of the valve is deeply concave.

*Structure and Affinities.*—The capitulum of *Zeugmatolepas mockleri* (see restoration, Pl. XCIV. fig. 14) closely resembles that of *Pollicipes*, especially in the number of valves, but differs (1) in the more specialized form of scutum which has a subcentral umbo, (2) in the size and position of the upper latera, which are elevated to occupy the whole of the interval between the scuta and terga, and (3) in the capitulum being longer than broad, and therefore of a more erect and *Scalpellum*-like shape. In this form the umbo of the scutum appears generally to be almost apical in young valves, and to become further removed from the apex with age, until it reaches about one-third of the distance of the valve from the apex. Some individuals, however, have the umbo further removed from the apex than others of the same size. All the valves are exceedingly variable, much more so than in any fossil pedunculate Cirripede with which I am acquainted; these variations are noted under the descriptions of the several valves.

*Zeugmatolepas mockleri* agrees more closely with *S. (?) cretæ* Steenstrup\* sp. from the Upper Senonian of Denmark than with any other species, and, indeed, *S. (?) cretæ* may quite well have been directly developed from *Z. mockleri*. Through the kindness of Dr. J. P. J. Ravn I have been able to examine examples of the known valves (scuta, terga, and carina) of *S. (?) cretæ* from

\* Steenstrup, J., Krøyer's Naturhist. Tidsskrift, Bd. i. 1837, p. 359; Bd. ii, 1839, p. 399, pl. v. figs. 1-3; Darwin, C. R., Pal. Soc. Mon. Foss. Lepadidæ, 1851, p. 45, pl. i. figs. 11 a-c.

the collection of the Mineralogical Museum of the University of Copenhagen, and Dr. Ravn informs me that this species has been found only in the Upper Senonian (Zone of *Scaphites constrictus*). Darwin doubtfully referred *S. (?) cretæ* to the genus *Scalpellum*, and observed (1851, p. 45): "Professor Steenstrup was originally inclined to believe that the capitulum [of *S. (?) cretæ*] was formed of only five valves; could this be proved, the species would very naturally rank with a small recent one from the Island of Madeira, which, owing to the upward growth of the scuta, and to certain peculiarities in the animal's body, I have felt myself compelled to raise to the rank of a genus, under the name *Ocynaspis*." An examination of the valves from Copenhagen University, and of some valves obtained by myself from the matrix of a specimen presented to the Geological Department of the British Museum by Copenhagen University, shows, at any rate, that we can no longer hold Steenstrup's view that *S. (?) cretæ* had only five valves. Among the above valves are some small lower lateral plates, which, although not so well preserved as those from the English Cenomanian Chalk, obviously belong to the same general type as those of *Zeugmatolepas mockleri*. *S. (?) cretæ*, together with the species now described, is included, for the reasons previously given, in the new genus *Zeugmatolepas*.

The scutum of *Z. cretæ* differs from that of *Z. mockleri* in that the umbo is further removed from the apex, being situated almost midway on the occludent margin, and in a greater portion of the valve near the basi-lateral angle being sharply upturned almost at right angles to the middle part of the basal margin. The lateral (or tergal) portion of the valve is not steeply inclined from the umbo, and there is no deep trough, as in *Z. mockleri*, running parallel with the upper occludent margin. These and other differences result, no doubt, from the difference in position of the umbo, and the consequent greater development of the tergal or lateral portion of the valve. The carina in *Z. cretæ* is relatively wider than in *Z. mockleri*, the central ridge is much more obscure, and in the tergum there is a much wider groove near the occludent margin. The whole of the valves in *Z. cretæ* are appreciably thinner. These differences, however, while deserving of specific distinction, appear to result from the further development of valves like those of *Z. mockleri*, and consequently I consider these two species to be closely and probably directly related.

#### Genus CALANTICA.

1825. *Calantica* Gray, 'Annals of Philosophy' (n. s.), vol. x. p. 101.  
 1907. *Calantica* Gray: Pilsbry, Bull. U.S. Nat. Mus. no. 60, p. 8.  
 1908. *Calantica* Gray: Pilsbry, Proc. Acad. Nat. Sci. Philadelphia, p. 106.

Capitulum with two whorls of valves, the upper comprising paired scuta, terga, and a carina, the terga occupying the whol

of the space between the scuta and carina; lower whorl comprising three pairs of latera, a rostrum, and a subcarina. Umbo of all valves apical.

The Oriental group, called by Pilsbry (1908) *Calantica* s. str., has the valves of the lower whorl low and wide, small, not concealing the bases of the valves of the upper whorl.

TITANOLEPAS\*, subgen. nov.

Valves of lower whorl large, high, but not incurved, and overlapping the bases of the valves of the upper whorl. Umbo of scutum subcentral and of the remaining valves apical.

*Genotype*.—*Titanolepas tuberculata*.

CALANTICA (TITANOLEPAS) TUBERCLATA Darwin sp. (Pl. XCV. figs. 1-10.)

1851. *Scalpellum tuberculatum* C. R. Darwin, Pal. Soc. Monogr. Foss. Lepadidæ, p. 43, pl. i. fig. 10.

1854. *Scalpellum tuberculatum* C. R. Darwin, Ray Soc. Monogr. Sub-class Cirripedia, Balanidæ, Synopsis et Index Systematicus, p. 634.

1854. *Scalpellum tuberculatum* C. R. Darwin: J. Morris, Cat. Brit. Foss. 2nd ed. p. 97.

1865. *Scalpellum tuberculatum* C. R. Darwin: J. W. Salter & H. Woodward, Cat. & Chart Foss. Crustacea, p. 27, pl. i. fig. 17.

1877. *Scalpellum tuberculatum* C. R. Darwin: H. Woodward, Brit. Mus. Cat. Brit. Foss. Crustacea, p. 143.

1886. *Scalpellum tuberculatum* C. R. Darwin: J. Kafka, Sitz.-Ber. k. böhm. Gesell. Wiss. Prag (1885), p. 565, pl. i. fig. 7.

1887. *Scalpellum tuberculatum* C. R. Darwin: A. J. Fritsch & J. Kafka, Crust. Böhmischen Kreidef. p. 6, fig. 9.

1888. *Scalpellum tuberculatum* C. R. Darwin: A. Peron, Bull. Soc. Sci. Yonne, vol. xli. (1887) p. 269.

*Diagnosis*.—Valves with fine ribs radiating from their apices and standing out as blunt spines at each zone of growth. Carina strongly convex transversely, with the parietes narrow and striated. Scutum with the umbo situated about one-third the extent of the valve from the apex, and with two ridges extending from the umbo, one to the basi-lateral angle, and the other to near the rostral angle. Tergum elongately diamond-shape, with a very acute basal angle. Valves of lower whorl with the inner apical half flat and strongly marked with growth-lines.

Remarking on this species, Darwin said (1851, p. 43): "Through the kindness of Mr. Harris, I have examined several valves, which I believe to belong to the same species: the specimens were found in the chalk detritus [of Charing, Kent], and, therefore, may have come from the Upper or Lower Chalk or Chalk-marl; but more probably from the Upper Chalk."

\* *titares* = White earth, Chalk.

*T. tuberculata* has since been recorded by J. Kafka (1886, p. 565) from the Cenomanian of Kamajk, Bohemia, and by A. Peron (1888, p. 269) from the Turonian of Yonne, France. Kafka mentions a single tergum only, and if his figure is accurate, it differs in certain characters from the original tergum from Charing. Peron recorded a small and a very large carina, but gave neither measurements nor figures; he drew attention to the fact that Darwin had supposed the species to come probably from the Upper Chalk, and said that so far as he knew it came from the Turonian.

*T. tuberculata* occurs fairly commonly in the Cenomanian Chalk Marl near Cambridge, and we have over 150 valves, including 22 valves of the lower whorl. From the Turonian *Terebratulina*-zone at Whyteleafe, Surrey, we have a single scutum, and from the Cenomanian Chalk Marl of Burham, Kent, a single rostrum.

*Type*.—The collection of the late Mr. Wm. Harris from the Chalk detritus of Charing, Kent, was acquired from his daughter in 1881, by the British Museum (Natural History). Several valves of *T. tuberculata* are represented in the collection, three of which—a carina (I. 14657), scutum (I. 14659), and tergum (I. 14658)—are mounted together on paper, and with them is a label bearing the name "*S. tuberculatum*" in Darwin's handwriting. These are probably the original specimens figured by Darwin, but there is no means of proving this since Darwin gave no measurements of the figured valves of this species. A further label (not in Darwin's handwriting) bearing the words "very valuable" was with the specimens, but whether this was meant to indicate that they are Darwin's original specimens must be left to individual opinion. I consider them to be the types, and since Darwin regarded the carina as the typical valve in *Scalpellum*, that valve is here taken as the holotype.

*Measurements*.—The valves of this species are exceedingly small, and to judge from these, the largest capitulum could not have measured much more than 5 or 6 mm. in length. Of the upper series of valves the largest examples measure respectively:—

Carina, I. 15850. Length 4.1 mm.; breadth 1.2 mm.

Scutum, I. 15843. Length (from apex to middle of basal margin) 2.5 mm.; breadth 2.6 mm.

Tergum, I. 15851. Length 4.3 mm.; breadth 2.6 mm.

*Distribution*. [? Cenomanian] Chalk detritus: Charing, Kent; Cenomanian, Chalk Marl: near Cambridge, and Burham, Kent; Cenomanian, Korytzaner Schichten: Kamajk, Bohemia; Turonian, *Terebratulina*-zone: Whyteleafe, Surrey; *Holaster planus*-zone: Armeau and Saint-Julien-du-Sault (Yonne), France.

*Description of Valves*.—Valves plainly ribbed longitudinally; the ribs are narrow, but become more prominent on the edge of each zone of growth, where the ribs are thicker and usually stand out as short blunt spines.

*Carina* (Pl. XCV. fig. 1) very narrow, either slightly bowed

inwards, straight, or bowed outwards; tectum strongly convex transversely, not carinate; basal margin almost rounded to bluntly angular; in young specimens, as shown by the periods of growth, the basal margin was almost straight; parietes slightly bent inwards, narrow, much less than half the width of the tectum, and marked with almost parallel growth-lines; inner surface of valve deeply concave for the lower two-thirds, the upper third of the valve being solid and marked with lines of growth, indicating that the valve projected freely to that extent.

*Scutum* (Pl. XCV. fig. 2) trapezoidal, umbo situated on the occludent margin about one-third the extent of the valve from the apex; almost flat to strongly convex; four-sided, the lateral or tergal margin slightly longer than the basal margin, with which it makes an angle of about  $70^\circ$ ; the basal margin much longer than the lower part of the occludent margin, with which it makes almost a right angle, the upper and lower portions of the occludent margin making an angle of about  $135^\circ$ ; the upper occludent margin, said Darwin, "homologically corresponds with the tergal margin of the other cretaceous species and with the upper, nearly straight, portion of the occludent margin in the tertiary *S. magnum* and the recent *S. vulgare*." The edge of the upper occludent margin is upturned and thickened, forming a prominent ridge, with its apex projecting beyond the lateral margin; a second prominent ridge extends from the umbo to the basi-lateral angle; a third ridge, barely perceptible in some specimens, extends from the umbo to the basal margin, near to the rostral angle. On the inner surface there is a deep hollow for the adductor muscle; along the upper occludent margin the inner surface is slightly raised, which corresponds to the outer thickened ridge, the space between the two ridges being concave; the inner ridge extends to the umbo, whence it becomes more pronounced and turns inwards, forming a prominent ridge above the hollow for the adductor muscle.

*Tergum* (Pl. XCV. fig. 3) elongately diamond-shape, slightly angular transversely; the occludent margin is thickened owing to the presence of a ridge on the outer and inner edge, corresponding with those on the upper occludent margin of the scutum; close and parallel to the occludent margin is a ridge which becomes prominent near the scutal margin and extends beyond it; a very prominent straight ridge extends from the apex, and thickens towards the very acute basal angle; scutal and lower carinal margins almost equal in length, and longer than the occludent and upper carinal margins, which latter are also of almost equal length and together make a right angle.

*Valves of the lower whorl* (Pl. XCV. figs. 4-8). These are ornamented externally like the scutum, tergum, and carina. The apical half of their inner surface is almost flat and marked with lines of growth, showing that these valves must have projected freely and overlapped the bases of the valves of the upper

whorl; the lower half is considerably concave. Umbo of valves apical. The valves are much less modified than is the case with the valves composing the lower whorl in the more typical forms of *Scalpellum*, and consequently their position in the capitulum is not so readily determinable. Seventeen of the valves are symmetrical, and five asymmetrical. Of the symmetrical valves, nine have an extremely concave basal margin with produced lateral angles (Pl. XCV. fig. 4) and probably represent rostra; five others have a much less concave basal margin (Pl. XCV. fig. 8) and may represent sub-carinæ. The valves just mentioned are thought to be rostra and sub-carinæ, owing to the pronounced concavity of the inner part of the valve near the base. The three remaining symmetrical valves probably represent median lateral valves (Pl. XCV. fig. 6). They differ from the supposed rostra and sub-carinæ in the smaller concavity of the inner basal part of the valve, and in the growth periods being formed of two downward curves which meet on the median line, gradually becoming more obtuse towards the basal margin. Of the asymmetrical valves, two are subtriangular in shape with a recurved acute apex, and probably represent carinal latera (Pl. XCV. fig. 7); the three others, which may be rostral latera (Pl. XCV. fig. 5), are about twice as wide as long, and are divided unequally by a fold extending from the apex to a position on the basal margin about two-thirds the distance from the rostral angle, the basal margin on each side being concave.

*Structure and Affinities.*—While Darwin had little doubt that the scutum and tergum figured by him belonged to the same species, he did not feel so certain with regard to the carina, and he pointed out that this valve had a close general resemblance to the same valve in *Pollicipes rigidus* J. de C. Sowerby. A specimen of *T. tuberculata* in the British Museum (Natural History), registered I. 14656, formerly in the Harris Collection, affords valuable evidence on this point, for it consists of the carina and the paired terga in position (Pl. XCV. fig. 9), and proves that the carina really does belong to the same species. Darwin stated also that the apex of the carina did not project freely in this species, but an examination of the carinæ from Charing, including the type, and of the numerous carinæ from the Chalk Marl of Cambridge, shows that the upper part of the inside of the valve is much thickened to one-third of its length from the apex (Pl. XCV. fig. 1 c), and this portion is marked with growth-lines, showing that it must have projected freely to that extent. Proof of this is afforded by the specimen I. 14656 from Charing (Pl. XCV. fig. 9), in which the carina and terga are in position, for the carina there projects freely.

The carina, scutum, and tergum only of *T. tuberculata* were known to Darwin, but the specimens from Cambridge include several other valves which enable us to add much to our knowledge of the capitulum. The ornamentation of these valves is so characteristic that no doubt can be entertained as to their belonging to this species. Although there are as many as twenty-

two valves\*, other than scuta, terga, and carinae, to judge by their structure, none appear to have formed upper latera, or at all events to fit between the scuta and terga, as do the upper latera in most forms of *Scalpellum*. Moreover, the form of the scuta and terga and the structure of their inner surface shows that the tergal margin of the scutum and the scutal margin of the tergum were in close proximity to each other. In this connection Darwin said (1851, p. 44): "I have no doubt that the ridge along the upper occludent margin of the scuta, and that on the occludent margin of the terga, together with their projecting points, are related to each other, owing to the close contact of these valves." It follows, therefore, that if no upper latera were present, the upper whorl of valves in *T. tuberculata* comprised only five valves, namely, a carina, a pair of terga, and a pair of scuta. The valves of the lower whorl, as mentioned in their description, must have overlapped the bases of the valves of the upper whorl, and if we are correct in designating these valves as rostrum, rostral latus, median latus, carinal latus, and sub-carina, the lower whorl would consist of at least eight valves, making thirteen valves for the whole capitulum (see restoration, Pl. XCV, fig. 10).

In the number and arrangement of the valves of the capitulum *Titanolepas tuberculata* approaches the forms of *Scalpellum* grouped by H. A. Pilsbry † under the genus *Calantica* Gray, and comes nearest to those included by him in the section *Scillelepas* Seguenza, of which the type is *S. carinata* Phillipi sp., from the Pliocene of Messina, Sicily. The capitula of the species grouped under *Calantica* closely resemble that of *Pollicipes*, but differ in that there is only a single basal whorl of valves, comprising three pairs of latera, a rostrum, and a sub-carina. The species included by Pilsbry under the section *Scillelepas* are chiefly characterized by the absence of an upper lateral plate in the upper whorl, which consequently consists only of five valves, and by the bases of the valves of the upper whorl being overlapped by those of the lower whorl; the umbo in all the valves is apical. While *T. tuberculata* agrees with these species in having five valves only in the upper whorl, and in the valves of the lower whorl overlapping those of the upper whorl, it differs from all the species included under the genus *Calantica* and the section *Scillelepas* by the umbo of the scutum being in a sub-central position.

We have in *T. tuberculata*, therefore, a species agreeing in all essential characters with the forms of *Calantica* (*Scillelepas*), except that it has a more specialized form of scutum. The

\* Two further valves have since been noticed among the Cirripede material from the Chalk detritus of Charing, Kent, in the British Museum (Natural History). These are identical with the valves from Cambridge, which I consider to be rostral, and are registered I. 14663, I. 14664. A further rostrum has been found in the Chalk Marl of Burham, Kent.

† H. A. Pilsbry, "On the Classification of Scapelliform Barnacles," Proc. Acad. Nat. Sci. Philadelphia. 1908, pp. 106-107; "The Barnacles (Cirripedia) contained in the Collections of the U.S. National Museum," Bull. U.S. Nat. Mus. No. 60, 1907, pp. 8-9.

fossil species that can be definitely referred to *Calantica* (*Scillaelepas*) are found in Tertiary rocks, viz. *Scillaelepas paronae* from the Miocene of the neighbourhood of Turin, Italy, and *S. carinata* and *S. ornata* from the Pliocene of Messina, Sicily, so that it is an important advance to show that a representative of the genus existed so far back in time as the Cenomanian. It is certainly remarkable to find that *T. tuberculata* had a more highly specialized scutum than the Tertiary and recent species, and to mark this advance in the evolution of the group, I place it in a new sub-genus, *Titanolepas*. This course is the more desirable since *T. tuberculata* may represent a side line of development from the ancestral *Scillaelepas* line, which, by the suppression of the lower whorl of valves, and by the umbo of the carina becoming sub-central, may eventually have given rise to the genus *Oxyaspis*.

For help in connection with this paper, I wish to express my indebtedness to Dr. F. A. Bather, Dr. W. T. Calman, Mr. C. P. Chatwin, and Dr. H. A. Pilsbry.

#### EXPLANATION OF THE PLATES.

All the specimens here figured are in the collection of the Geological Department of the British Museum.

##### PLATE XCIV.

*Zeugmatolepas mockleri* Withers, gen. et sp. n.

- Fig. 1. Carina. Cenomanian, Chalk Marl: near Cambridge. I. 15820. *a*, outer view; *b*, side view; *c*, inner view.  
 2. Carina, I. 15821. *a*, outer view; *b*, side view; *c*, inner view.  
 3, 4, 5, 6. Scuta (various forms), I. 15822-I. 15825.  
 7. Tergum, I. 15826. } *a*, outer view; *b*, inner view.  
 8. Upper latus, I. 15827. }  
 9. Rostrum, I. 15828. }  
 10. Several valves in position, including the carina, I. 15829.  
 11. Holotype. Nearly complete capitulum showing the left side, I. 15830.  
 12. Several valves in position, I. 15831.  
 13. Nearly complete capitulum showing the right side, I. 15832.  
 14. Restoration of capitulum based on the above material from the Chalk Marl of Cambridge. *c.*, carina; *s.*, scutum; *t.*, tergum; *u.l.*, upper latus; *r.*, rostrum; *l.l.*, lower latera; *s.c.*, sub-carina.

Figs. 1, 2, 4, 9-13,  $\times 10$  diameters; figs. 3, 5-8, 14,  $\times 5$  diameters.

##### PLATE XCV.

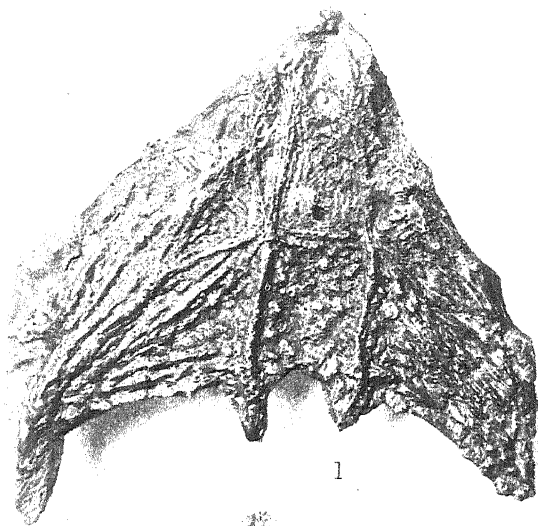
*Calantica* (*Titanolepas*) *tuberculata* Darwin sp.

- Fig. 1. Carina. Cenomanian, Chalk Marl: near Cambridge. I. 15842. *a*, outer view; *b*, side view; *c*, inner view; *d*, transverse section near apex.  
 2. Scutum, I. 15843 (figure reversed).  
 3. Tergum, I. 15844. } *a*, outer view; *b*, inner view.  
 4. Rostrum, I. 15845. }  
 5. Rostral latus, I. 15846. }  
 6. Median latus, I. 15847. }  
 7. Carinal latus, I. 15848 (figure reversed). }  
 8. Sub-carina, I. 15849. }  
 9. Carina and pair of terga in position. [<sup>?</sup> Cenomanian] Chalk detritus; Charing, Kent. I. 14656.  
 10. Restoration of capitulum, based on disconnected valves from the Chalk Marl of Cambridge. *c.*, carina; *s.*, scutum; *t.*, tergum; *r.*, rostrum; *r.l.*, rostral latus; *m.l.*, median latus; *c.l.*, carinal latus; *s.c.*, sub-carina.

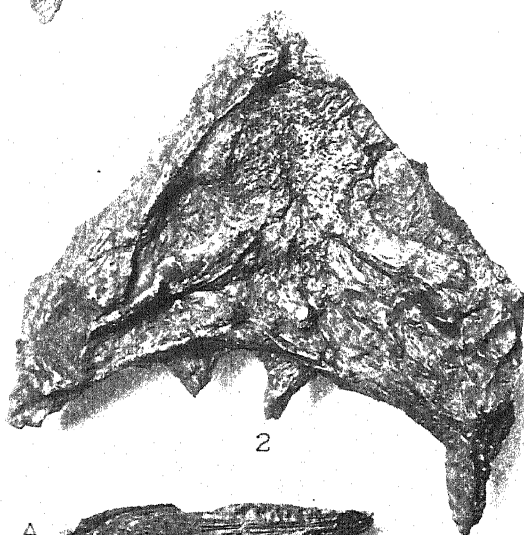
Figures 1-10  $\times 10$  diameters.







1



2



A

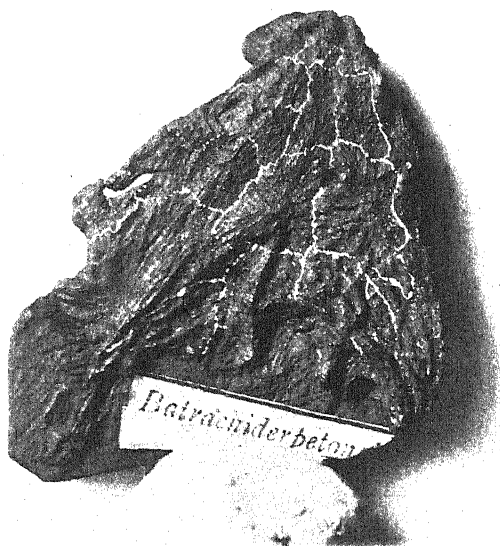


B

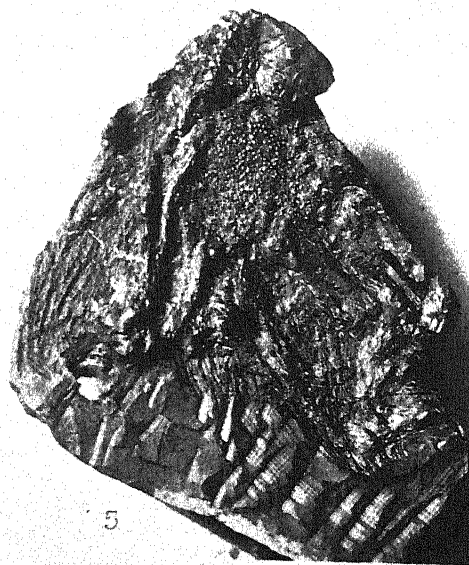
3

BATRACHIDERPETON LINEATUM.





4



5

BATRACHIDERPETON LINEATUM.

55. *Batrachiderpeton lineatum* Hancock & Atthey, a Coal-Measure Stegocephalian. By D. M. S. WATSON, M.Sc., Lecturer on Vertebrate Palæontology in University College, London \*.

[Received May 20, 1913: Read October 28, 1913.]

(Plates XCVI. & XCVII.,† and Text-figures 162-167.)

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Amongst the wonderful series of vertebrate fossils in the Hancock Museum, Newcastle-on-Tyne, derived from the Low Main Seam of Newsham Colliery, a small stegocephalian *Batrachiderpeton* is represented by excellent material, which is described as completely as possible in this paper.

#### SKULL.—*Material.*

- I. A nearly complete skull with the ornament and palate well preserved. The type specimen. (Atthey collection.)
- II. A complete skull showing with great clearness all the sutures on the top of the head. (Atthey collection.)
- III. A much disarticulated skull of importance in ascertaining the structure of the palate. (Atthey collection.)
- IV. Half of a badly-preserved skull, showing well the maxillary and palatine teeth. (Dinning collection.)

#### *Shape of the Skull.*

All the specimens are crushed flat, so that the shape of the skull has to be settled by indirect means. It is triangular in plan, the postero-lateral corners being much produced into long "cornua." Specimen II. shows that there were almost vertical cheeks, as on the right side this part was turned under and crushed on to the lower surface of the roof of the skull, whilst the left side is pressed outwards. This crushing has only very slightly distorted the palate, and the distance between the two quadrates is almost identical with that between the spot where the cheek is turned under on the right side and the corresponding point on the left side.

There is a pineal foramen of medium size almost exactly halfway between the point of the nose and the back of the head in the middle line. The orbits are laterally placed and lie entirely in front of the middle of the skull. The small anterior nares are also laterally placed.

The structure of the cranial roof will be best understood from

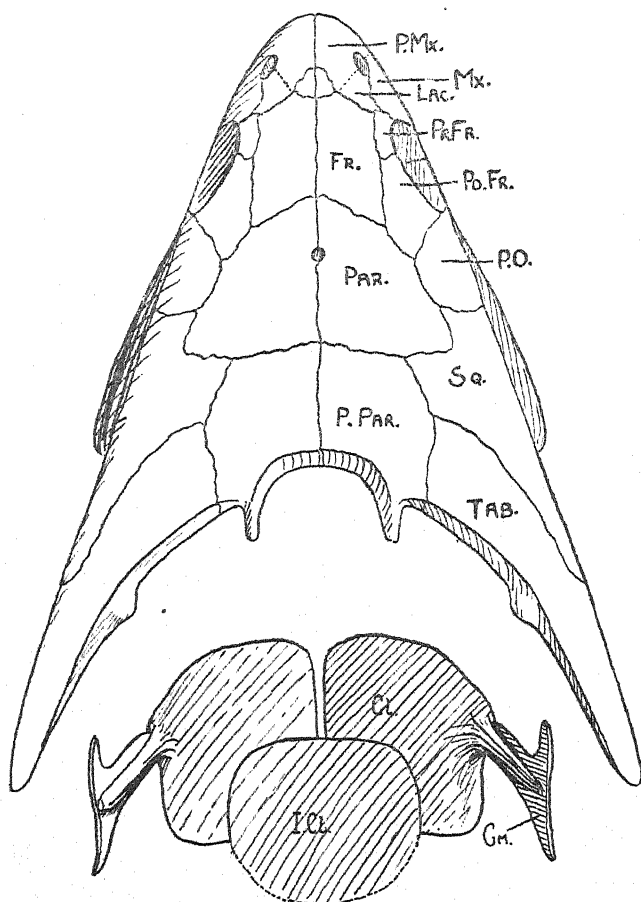
\* Communicated by Prof. J. P. HILL, D.Sc., F.R.S., F.Z.S.

† For explanation of the Plates see p. 962.

text-figs. 162 & 164. All the sutures drawn with solid lines in these figures can be clearly seen in specimen II.

The interesting features are the great development of the

Text-fig. 162.



*Batrachiderpeton lineatum*. Dorsal aspect of the restored skull and clavicular apparatus.  $\times 1\frac{1}{2}$ . Skull mainly founded on specimen II., from which all the sutures are taken, and the pectoral girdle restored from the bones of specimen III., which is a smaller individual, enlarged to correspond in size with the skull.

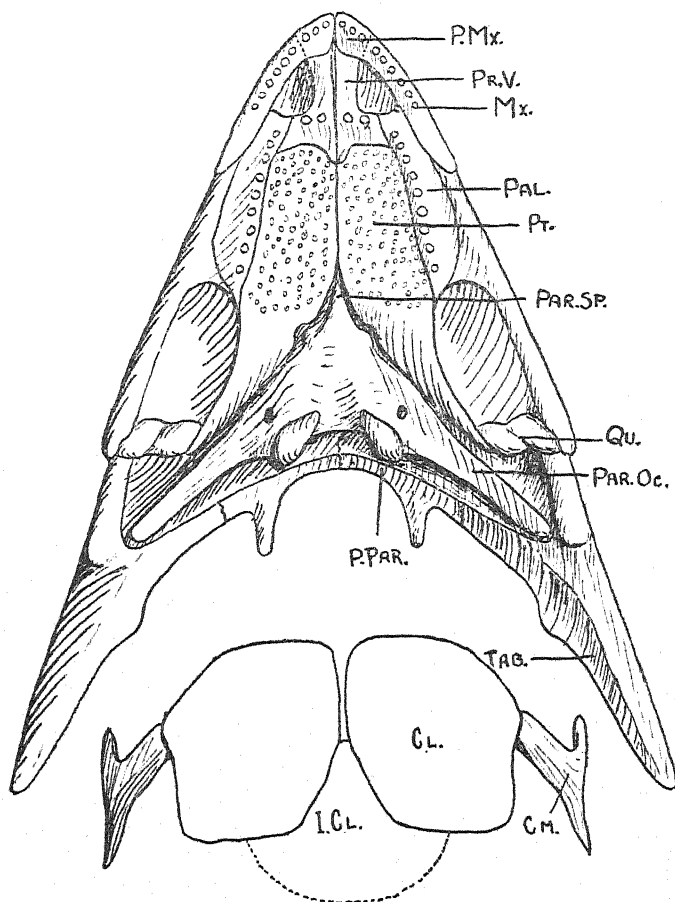
Reference letters:—CL., Clavicle; CM., Cleithrum; FR., Frontal; I.CL., Interclavicle; LAC., Lachrymal; Mx., Maxilla; P.Mx., Premaxilla; P.O., Postorbital; P.PAR., Postparietal; PAR., Parietal; Po.Fr., Postfrontal; Pr.Fr., Prefrontal; Sq., Squamosal; TAB., Tabulare.

horns, formed entirely by the squamosals and tabulares, and the correspondingly large size of the post-parietals.

The extremely small size of the nasals is an interesting feature.

The sutures separating the lachrymals from the premaxillæ are not certain, but there is a separation and displacement of the bones at the dotted line which has probably taken place along the suture.

Text-fig. 163.



*Batrachiderpeton lineatum*. Ventral aspect of the restored skull and clavicular apparatus.  $\times 1\frac{1}{2}$ . Skull mainly from specimen I., sutures from specimen III., clavicles, etc., from specimen III.

Reference letters as before with:—QU., Quadrate; PAL., Palatine; PAR.Oc., Paroccipital process; PAR.SP., Parasphenoid; Pr.V., Prevomer; Pt., Pterygoid.

The palate is of great interest; in the restoration the general features are drawn from specimens I., II., and IV., and the sutures are introduced from specimen III., where the pterygoids, palatines, and prevomers are disarticulated.

*Basis cranii.*—The basis cranii is much crushed in all the specimens and was apparently very thin and delicate.

The two large exoccipital condyles are clearly shown in I. and II. They are rounded from front to back and to a less extent from side to side. The bone between them is extremely thin, but no doubt is partly composed of basioccipital. The basisphenoid in I. is slightly better preserved; it bears two very small basipterygoid processes only very obscurely indicated. In front of this region it is produced into a narrow rostrum undoubtedly parasphenoid.

Extending outwards and backwards from the sides of the basis cranii are two long, very delicate processes which are shown, much crushed and broken, in specimens I., II., and III. In specimen I. on the right side, a small foramen is rather obscurely indicated on the process about a third of its length from the middle line, this opening can only be the fenestra ovale. The process is probably mainly opisthotic, with the prootic forming some of its front border. Immediately above the exoccipital condyle in the same skull is a foramen for cranial nerves ix. and x.

The outer end of the opisthotic articulates as usual with a facet on the under surface of the tabulare.

The quadrates are well shown in specimens I. and II. They are small bones with a well-developed trochlear condyle, the outer border is articulated with the quadrato-jugal, there being probably no foramen between the two bones.

The upper end of the quadrate is supported by a downwardly directed flange from the squamosal, well seen in specimens I. and III. The inner border of the quadrate is continued by a short thin pterygoid process (specimen I.).

The pterygoid is a large bone which articulates by a small facet with the basipterygoid process of the basisphenoid (specimen I.). Behind this it is continued as a deep but thin plate, the posterior ramus, which articulates distally with the quadrate and whose upper border has a suture with a continuation of the descending flange of the squamosal mentioned above. The anterior part of the bone forms a broad flat plate covered with a shagreen of small sharp teeth. The anterior border of the plate is in contact with the prevomer and the lateral border with the palatine.

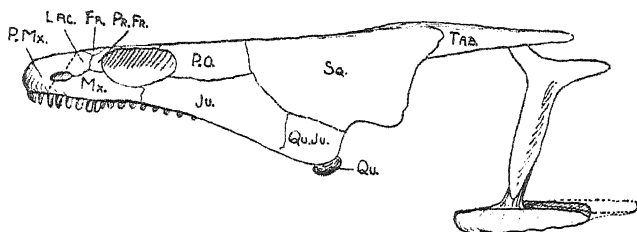
The palatine bears a single row of nine medium-sized swollen teeth, and its outer border articulates with the jugal and maxilla. There is apparently no transpalatine.

The prevomer is a small bone with a median symphysis with its fellow; it forms a good deal of the inner border of the posterior nares and bears two teeth placed transversely; its exact relations to the palatine are not certain.



The premaxilla appears to bear three teeth, but the suture separating it from the maxilla with six teeth is not quite certain.

Text-fig. 164.



*Batrachiderpeton lineatum*. Left lateral aspect of the restored skull and clavicular apparatus. Skull from specimen II., clavicle, etc., from specimen III.  $\times 1$ .

Reference letters as in former figures with :—Ju., Jugal; Qu.Ju., Quadrato-jugal.

#### LOWER JAW.—*Material*.

Specimen III. The perfect left ramus and disarticulated parts of the right ramus of the same individual. Although the posterior part of the right ramus, composed of the angular, surangular, and prearticular, is not well preserved, this specimen is of great importance because it gives the most satisfactory evidence of the front of the mandible, the dentary and splenial being slightly separated and completely free from matrix on the outer and largely so on the inner side.

Specimen V. A perfect right ramus showing well the suture between the prearticular and the angular. (Atthey collection.)

Specimen VI. A perfect right ramus. (Barkas collection.)

Specimen VII. An isolated dentary. (Atthey collection.)

The various specimens are crushed in different directions and suggest that the jaw had a considerable cavity and was perhaps nearly circular in cross section.

There is a distinct though short postarticular process.

The articular is well ossified though small; it bears an articular facet adapted to the trochlea quadrati.

The suture between the surangular and angular is not clearly shown in any specimen. The angular is a very large bone extending nearly up to the symphysis; it forms the lower part of the jaw, and its inner border articulates by a suture (specimen V.) with the prearticular, from which it is separated by a small oval internal mandibular vacuity.

The prearticular is a large bone covering the inner side of the articular and extending well forward.

The dentary is a fairly large bone overlapping the surangular and angular behind; it bears eleven or twelve swollen teeth and has a symphysis with its fellow; its lower border has a suture

with the splenial. The splenial has a symphysis with its fellow and is entirely a bone of the outer side of the jaw, as is conclusively shown in specimen III.

Text-fig. 165.

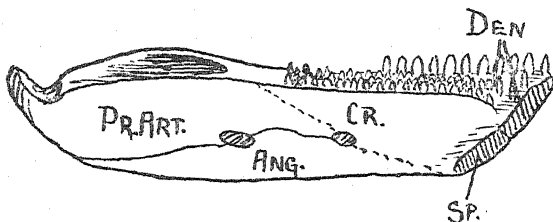


*Batrachiderpeton lineatum*. Right ramus of the lower jaw, outer aspect.  $\times 2$ .  
Outline and sutures from specimen III.

Reference letters:—ANG., Angular; DEN., Dentary; SP., Splenial; SUR.ANG., Surangular.

The complete jaws show extremely well a great patch of small conical teeth lying inside those of the dentary. Specimen III. shows conclusively that these do not belong to the dentary, the splenial, the angular, or the prearticular, so that it is quite certain that there is another element, which can only be the coronoid.

Text-fig. 166.



*Batrachiderpeton lineatum*. Left ramus of the lower jaw, inner aspect.  $\times 2$ .  
Drawn from specimens III., V., & VI.

Reference letters as on text-fig. 165 with:—CR., Coronoid; PR.ART., Prearticular.

Between the coronoid, prearticular, and angular there is a small vacuity.

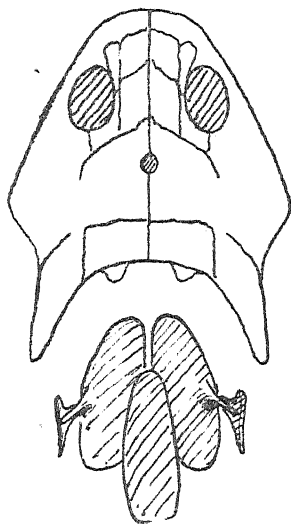
### *Pectoral girdle.*

Specimen III. retains both clavicles and a cleithrum.

The clavicle is composed of a flat ventral plate with an ornament of strong radiating ridges, from the upper surface of which within the lateral border an almost cylindrical process rises abruptly, this slopes slightly backwards and outwards and gives attachment to the cleithrum. The dorsal surface of the ventral plate of the clavicle shows clearly the impression of the part of

the interclavicle which overlaid it, and enables the width of the latter bone to be accurately determined.

Text-fig. 167.



*Ceraterpeton reticulatum* H. & A. Restored dorsal surface of skull and clavicular arch.  $\times 4$ .

The cleithrum is a T-shaped bone, flat, and ornamented by fine grooves, the upright of the T is affixed to the vertical process of the clavicle.

#### *Discussion of the Skull.*

One of the most interesting features of the skull is the reduction of the number of bones in the temporal region. The primitive amphibian has in the temporal region three bones, the squamosal, supratemporal, and intertemporal, all of which occur in the primitive reptile *Seymouria*. It is important to discover which of these bones is really present in *Batrachiderpeton*.

In the primitive amphibians "*Loxomma*" and *Pteroplax* all three bones are present in a typical manner and also the squamosal; that is, the outer bone, which articulates with the quadrato-jugal, is well characterized and differentiated from the other two by the fact that its posterior border is bent down in front of the otic notch and articulates with the upper edge of the quadrate ramus of the pterygoid, it also passes down behind the quadrate itself, overlapping a good deal of its posterior surface. Neither the intertemporal nor supratemporal has any connection whatever with the pterygoid or quadrate.

The conditions in these primitive amphibia are those which

always occur in the large Stegocephalia, modified of course by changes in the shape of the skull. I have seen them in:—*"Loxomma,"* *Pteroplar*, *Batrachosuchus*, *Cyclotosaurus*, *Plagiosternum*, *Trematosaurus*, *Micropholis*, *Capitosaurus*, *Aphaeramma*, *Bothriceps*, *Archegosaurus*.

In *Batrachiderpeton* the squamosal is united to the pterygoid, and covers the back of the quadrate, not by the turning down of its hinder edge but by a special descending flange, a difference depending entirely on the development of the "horn" which has carried the otic notch, which, in all amphibia and reptiles where it is present, lies between the tabulare and the squamosal, far out and backwards. The great sheet of squamosal which lies behind the quadrate is in fact a new development, the original posterior border being now represented by the flange.

There is hence no doubt that the single temporal bone remaining in *Batrachiderpeton* is the outer of the original three. That this is really the homologue of the mammalian squamosal, I hope to be able to show in a subsequent paper. The other bones of the top of the skull do not call for special notice.

The palate of *Batrachiderpeton* is of very great interest. I pointed out recently that the type of palate found in *"Loxomma,"* with a large single basioccipital condyle, basiptyergoid processes on the basisphenoid, and large pterygoids, which leave only a very small interptyergoid vacuity divided by a narrow parasphenoid, is the primitive type of amphibian palate, because it agrees very closely with that of the Crossoptrygian fish, and because no palate with large parasphenoid and interptyergoid vacuities is known to occur in the Coal-Measures or Lower Carboniferous. From known types it is possible to pick a morphological although non-phylogenetic series showing exactly how the change from the primitive palate to the typical palate of *Capitosaurus* has taken place. *Eryops*, which, as shown by v. Huene's recent extremely interesting paper, has a quite large basioccipital and basiptyergoid processes of the basisphenoid, and in which the parasphenoid and interptyergoid vacuities are only of moderate size, is exactly intermediate between the primitive type and that found in the Triassic forms, where the basioccipital and basisphenoid are very much reduced and the pterygoids are supported by sutural union with the edges of the parasphenoid. The palate of *Batrachiderpeton* agrees with the primitive type, in having large pterygoids meeting in the middle line and articulating with basiptyergoid processes of the basisphenoid. It differs, however, in that it has already completely replaced the basioccipital condyle by a pair of exoccipital condyles, just as have the later large Stegocephalia.

#### *Discussion of the Lower Jaw.*

Except that it is not known whether an epicoronoid was present or not, the lower jaw of *Batrachiderpeton* is extremely like that

of "*Loxomma*" in its structure, particularly in the fact that the splenial is entirely a bone of the outer side of the jaw, which is proved in the most conclusive manner by specimen III.

In later Stegocephalia the splenial (as shown, for example, in *Eryops*, *Anaschisma*, *Bothriceps*, and "*Labyrinthodon*" *leptognathus*), although it still has a good exposure on the outer surface, has also a large flange running up on the inner side of the jaw to the coronoid.

In Reptilia the internal part of the splenial is always larger than the external, and in later reptiles this latter part disappears altogether.

It thus seems certain that the trend of evolution of the splenial has been directed to gradual growth of an internal flange at the expense of the external part of the bone which alone occurs in the primitive amphibia.

In correlation with this development is a reduction of the coronoid and a complete loss of the epicoronoid.

As the angular is to all appearance a serial homologue of the splenial, it is probable that it may have tended in early Amphibia to pursue a similar course of change, in which case we may suppose that in primitive forms the suture between the angular and the prearticular probably ran along the lower border of the jaw just as does the suture (when there is one) between the coronoid and the splenial.

This type of jaw, which we have arrived at hypothetically, is actually realized in Crossopterygian fishes, *Megalichthys* being the best type.

The structure of the jaw in Palæozoic Crossopterygians was first accurately made out by Traquair in *Rhizodus* and *Rhizodopsis*.

I give here an account of the jaw of *Megalichthys* and have also examined those of *Holoptychius* and *Osteolepis*, which agree in general structure.

In *Megalichthys* the dentary is a large bone narrowing from front to back, where it ends in a point. It bears throughout its border a single row of small pointed teeth, within which at the anterior end are one or two large "laniary" teeth. Its lower border overlaps three bones, the splenial, angular, and surangular.

The splenial has an articulation with its fellow; it lies entirely on the outer side of the jaw and its lower border is entirely free. Its oblique posterior edge overlaps the angular.

The angular is a bone similar to the splenial, except that it has of course no symphysis and its lower border articulates with the coronoid.

The surangular is overlapped by the angular, which it greatly resembles; it covers the outer side of the well-ossified articular.

\* The combined prearticular and coronoid is a very large bone running forward from the inner side of the articular nearly to

\* A specimen of *Glyptolepis paucidens* in the Manchester Museum seems to show a clear suture between the short prearticular and the coronoid.

the front of the jaw; in front it ends freely in a point, its lower border articulates with the angular and surangular, and its upper border with the epicoronoids; the inner surface of the bone is covered with a shagreen of small denticles.

The epicoronoids are two small bones lying between the upper edge of the coronoid and the dentary. The posterior is a short bone forming the front of the suprameckelian vacuity, and bearing two large teeth and the pits for their replacing teeth. It is separated from the anterior epicoronoid by a large round foramen. The anterior bone bears one tooth and its replacing tooth-socket.

The jaw of *Megalichthys* differs slightly from that of *Rhizodus*, *Rhizodopsis*, etc., in there being only three bones besides the dentary on the outside of the jaw, instead of four, and only two epicoronoids instead of three.

Comparison of this jaw with that of "*Loxomma*" will, I think, justify the nomenclature used here, even the direction of overlap of the bones being the same in the two types.

#### *Systematic position of Batrachiderpeton.*

The classification of the smaller stegocephalian Amphibia, so abundant in the Coal-Measures and Permian Rocks of Europe and North America, is in such confusion, to which some recent work has added, that it is at present only possible to proceed by reference to individual specimens which have been well described. The difficulty of identifying species and the rashness with which genera often founded on very imperfect materials have been extended to include other types often of very distinct structure, combined with the great technical difficulties of working on small and often badly-preserved animals, make any wide divisions at present of very doubtful value.

*Batrachiderpeton* in the forward position of its orbits and the great "cornua" at once recalls *Ceraterpeton*, originally described by Huxley from Kilkenny. The type-specimen of this latter genus is badly preserved, so that the sutures of the cranial roof are not clearly shown, although it seems probable that the apparent sutures are real, in which case there are many resemblances between the two types.

To the type-species *Ceraterpeton galvani* two other specimens have been assigned—Ward's specimen from North Staffordshire described by C. W. Andrews, and a specimen from Kilkenny figured by A. Smith Woodward. These two specimens agree extremely closely in size and in the shape of the skull, but they differ from the type in being only about one-half of the size and in having a narrower skull. In the Hancock Museum there are three specimens closely similar from the Low Main seam of Newsham, one of which is the type of Hancock and Atthey's

*Urocordylus reticulatus*. These three specimens agree very closely in measurements and in all characters which can be observed; they are undoubtedly conspecific. They also agree exactly with Andrews' and Smith Woodward's specimens in the proportions of the skull and body, and in size, but differ from Andrews' specimen very markedly in the character of their cranial ornament, which is almost entirely composed of ridges instead of pits. They must hence be regarded as specifically distinct.

In text-fig. 167 (p. 955) I have given a drawing of the top of the head with such sutures as are clearly visible in one of the Newcastle specimens preserved in counterpart; this should be compared with Dr. Andrews' figure. It is certain that the pterygoids met in the middle line, as in *Batrachiderpeton*, although the detailed structure of the palate cannot be made out.

One important feature, shown clearly by the type-specimen of "*Urocordylus*" *reticulatus*, is the T-shaped cleithrum, also shown in Dr. Woodward's figure, where it is interpreted as scapula. Such a shaped bone is known in no other animal except *Batrachiderpeton*, and seems to show definitely that "*Urocordylus*" *reticulatus* and *Batrachiderpeton* are closely related. The very remarkable clavicle is also identical in the two types.

Whether *Urocordylus reticulatus* H. & A. really belongs to the genus *Ceraterpeton* is uncertain, but it is probable that it does; in any case, by calling it *Ceraterpeton reticulatum* in full, no trouble will arise; it seems probable that it is not *Urocordylus*.

One of the most marked features of *Ceraterpeton* is the expansion and corrugation of the distal ends of the neural and hemal spines; the meaning of this condition, which occurs throughout the column, is obscure. It also occurs in *Ceraterpeton galvani*, *Urocordylus wandesfordii*, *Scincosaurus crassus*, *Ptyonius æstocephalus*, and other types. As there is no definite evidence that these types cannot be related, it is natural to assume that they are; but it must be remembered that any such relation can only be slight, for if Fritsch's restoration of the skull of *Scincosaurus crassus* is at all correct, it differs very greatly from *C. reticulatum* and *Batrachiderpeton*.

Another type which appears to be related is *Diceratosaurus punctolineatus* Cope, recently described by Jækel. The palate of this type is extremely like that of *Batrachiderpeton*, differing in minor features of the dentition, in the larger interpterygoid vacuity, and in the presence of a transverse bone.

If we suppose, as is quite probable, that some of the sutures of the cranial roof were invisible, it is probable that the skull structure was very like that of *Ceraterpeton reticulatum*. On the other hand, this type has not the T-shaped cleithrum and peculiar neural arches of the latter form.

Assuming, as seems justifiable, that *Batrachiderpeton* is allied to *Ceraterpeton reticulatum*, it is of interest to see the differences between the two types. *Ceraterpeton reticulatum* is obviously the

less modified, and the following list shows the direction of change in passing to *Batrachiderpeton*:—

1. Increase in the relative size of the "cornua" involving larger squamosals, postparietals, and tabulares.
2. More anterior position of the orbits.
3. Great decrease in size of the nasals.
4. Broadening of the clavicles and interclavicle.

The most interesting comparison, however, is with *Diplocaulus*, a type which Jäkel has already brought into relation to *Ceraterpeton*.

Comparison of text-fig. 162 (p. 950), the dorsal surface of the skull of *Batrachiderpeton*, with the figures of the skull of *Diplocaulus* given by Williston & Case, shows a very striking resemblance, particularly in the way in which the horn is developed, by enlargement of the squamosal (prosquamosal of Williston & Case), tabulares, and postparietals (supra-occipital plate of Williston & Case).

If the bone regarded by Williston as a nasal is compared with the undoubted lachrymal of *Batrachiderpeton* no doubt of its identity can arise, it being evident that the nasals, extremely small in *Batrachiderpeton*, are quite lost in *Diplocaulus*.

It also seems extremely probable that the bone called squamosal by Williston & Case is really the postorbital dragged out from the border of the orbit by the development of the horn.

The only other important difference shown on the top of the skull lies in the fact that in the earlier type the frontal is excluded from the orbit, whereas in the American form it forms much of the border of that opening. This depends on the different position of the orbits, which in *Batrachiderpeton* are laterally directed, whilst in *Diplocaulus* they look directly upwards. It is in every way probable that this difference depends entirely on the habits of the animals in question.

The skull of *Batrachiderpeton* shows no grooves for lateral line organs, and it seems likely that the animal was not very aquatic; and as its skull was probably of only moderate size, it is possible that it pursued an ordinary life.

Case, apparently justly, regards *Diplocaulus* as living in the mud at the bottom of ponds, and its head is so enormous that it must have been carried flat on the ground. Such a habit of life is inconsistent with laterally placed eyes, which would therefore necessarily migrate to the dorsal surface as in all flat-bodied bottom-dwelling fishes, e. g., *Lophius*, *Raia*, *Solea*.

The clavicular apparatus of *Diplocaulus* is very similar to that of *Batrachiderpeton*. The clavicles in both types consist of a flat ventral plate, from the upper surface of which a cylindrical process rises dorsally within the lateral edge.

The vertebral column of *Diplocaulus* is now well known. The



presacral vertebrae, 16 in number, have an elongate hour-glass-shaped "centrum" and elongated neural arches with low elongate spines. There are two processes for the rib, the upper carried by the arch, the lower by the "centrum." There are hypapophysial in addition to the ordinary zygapophysial articulations. The caudal vertebrae have no rib articulations and expanded hæmal arches fused into the "centrum."

The vertebral column of *Ceraterpeton* is not well known, but the Newcastle specimen of *C. reticulatum* seems to show the following characters:—There are about 18 presacral vertebrae with hour-glass-shaped centra, long neural arches and spines almost certainly with hypapophysial in addition to the ordinary articulations, and a single process nearly in the centre of the vertebra for the rib; this may be partly carried by the arch. The later caudals differ in having no rib articulation and in having large expanded hæmapophysial spines fused onto the centrum.

The vertebral columns of the two types are, in fact, very similar, differing apparently only in the fact that in *Diplocaulus* the head of the rib is double, whereas in *Ceraterpeton reticulatum* it is single.

The shortness of the neural and hæmal spines of *Diplocaulus* may be due merely to the flatness of that animal.

The lower jaw of *Diplocaulus* as described by v. Huene agrees very well with that of *Batrachiderpeton*, the inner row of teeth at the front being probably borne on the real coronoid, and v. Huene's complementare being an epicoronoid.

In fact, the only important difference between the two types lies in the palate. *Diplocaulus* differs in its palate from *Batrachiderpeton* exactly as does *Eryops* from *Loxomma*.

The dentitions in the two types are identical in general lines. The differences are that in *Batrachiderpeton* there are large pterygoids meeting in the middle line and supported by the basisphenoid, in *Diplocaulus* there are large interpterygoid vacuities and the pterygoids are supported by the parasphenoid.

I have already endeavoured to show that in the large Stegocephalia this change actually takes place, a view which if correct removes all difficulty of regarding *Batrachiderpeton* and *Diplocaulus* as very closely allied.

Finally, it may be noticed that the characters in which *Diplocaulus* differs from *Batrachiderpeton* are exactly those in which the latter differs from *Ceraterpeton*:—

1. Increase in relative size of the cornua, involving larger squamosals, postparietals, and tabulares.
2. More anterior position of the orbits (and their dorsal position).
3. Complete loss of the nasals.
4. Broadening of the clavicles and interclavicles.

I wish to express my thanks to the Committee of the Northumberland and Durham Natural History Society and to E. L. Gill, Esq., Curator of the Hancock Museum, for the kindness with which they have allowed me to work on the wonderful material in their Museum.

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## EXPLANATION OF THE PLATES.

## PLATE XCVI.

- Fig. 1. Skull of *Batrachiderpeton lineatum* H. & A. Specimen I. (type-specimen),  $\times 1\frac{1}{2}$ . Dorsal aspect.
2. Same specimen as fig. 1. Palatal aspect.
3. Ramus of the lower jaw of *Batrachiderpeton lineatum*,  $\times \frac{5}{8}$ .
- A. Specimen VI. Right ramus, outer aspect.
- B. Specimen III. Left ramus, inner aspect, showing very clearly the patch of teeth on the coronoid.

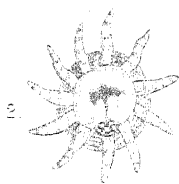
## PLATE XCVII.

- Fig. 4. Skull of *Batrachiderpeton lineatum* H. & A. Specimen II.,  $\times 1$ . Dorsal aspect.
5. Same specimen as fig. 4. Palatal view

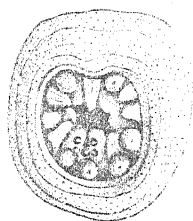




1.



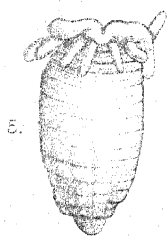
2.



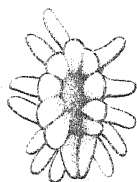
3.



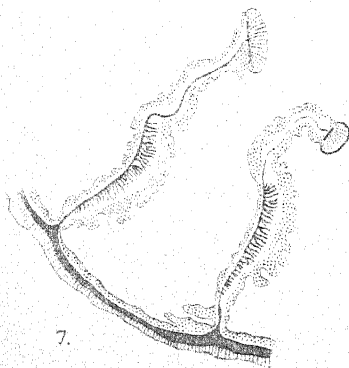
4.



5.



6.



7.



8.

West, Newman imp.

1-4. PEACHIA QUINQUECAPITATA.  
5-7. BICIDIUM ÆQUOREÆ 8. B. PARASITICUM.

## 56. On two New Actinians from the Coast of British Columbia. By J. PLAYFAIR McMURRICH, C.M.Z.S.

[Received August 1, 1913: Read November 11, 1913.]

(Plate XCVIII.\*)

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<i>Peachia quinquecapitata</i> , sp. n. ....		963
<i>Bicidium æquoreæ</i> , sp. n. ....		967

The two forms described below were obtained during a visit to the Marine Station maintained by the Canadian Government at Departure Bay, Vancouver Island. They are of especial interest from the probability that they represent stages of a single species, and belong to a group that has not yet been described as occurring on the west coast of North America. Since the specific identity of the two forms is only a probability, it has seemed well to regard them for the present as distinct, and even, for reasons given below, to assign them provisionally to different genera.

*PEACHIA QUINQUECAPITATA*, sp. n. (Pl. XCVIII. figs. 1-4.)

This form (fig. 1) was dredged by Dr. C. McLean Fraser in Nanoose Bay, Vancouver Island, in 15-20 fathoms. In the majority of the individuals the base is depressed in the centre and smaller than the column. It is thin, and in all cases shows clearly the lines of insertion of the mesenteries as well-marked inversions, so that it can have possessed but very slight adhesive powers, if any. In one individual the attachments of the mesenteries did not quite reach the centre of the base, but ended abruptly a short distance from it, leaving a circular central area which was exceedingly thin, but nevertheless not perforated. In other examples this condition did not occur, the insertions of the mesenteries extending quite to the centre, so that there were no indications of a terminal pore, such as has been described by Gosse (1860) in *P. hastata*.

The column (fig. 1) is almost cylindrical, though usually contracting somewhat towards either extremity and, in some examples, is grooved by twelve well-marked inversions, although in others these are quite indistinct. Examined under a lens the surface is seen to be studded with minute elevations, which are all the more noticeable by being of a paler colour than the general surface. No foreign particles were adhering to these elevations in any of the examples studied, and, as I had no opportunity for examining living specimens, I cannot say whether they had the power of adhering to surfaces with which they came into contact, as seems to be the case with the similar

\* For explanation of the Plate see p. 972.

structures of *P. hastata* (Haddon and Dixon, 1885) and *P. tripitata* (Andres, 1883).

There was no differentiation of the upper part of the column to form a capitulum, nor was there any distinct margin.

The tentacles are twelve in number, arranged in a single cycle. They are of moderate length and stoutness, obtuse or tapering slightly at the tips, but not capitate, and frequently with longitudinal grooves.

The lips are elevated considerably above the level of the disk, and show only a single siphonoglyph (fig. 2), which is completely separated from the rest of the stomatodæum by the fusion of its lips throughout the greater part of their extent. At least this was the case in three individuals that I examined anatomically, and it would seem, therefore, to be of general occurrence. Sedgwick (1884) has described the same peculiarity as occasional in *P. hastata*, but it is not mentioned by other authors who have studied the anatomy of that species (Haddon, 1885, 1889; Faurot, 1890, 1895).

The general surface of the stomatodæum is longitudinally grooved along the lines corresponding to the insertions of the mesenteries, and each lip is raised in the intervals between the grooves into five rounded elevations, which correspond with the intervals between the perfect mesenteries, with the exceptions of those between the directives. One of these latter is quite small and the other is represented by the margins of the siphonoglyph, which, although not elevated to any great extent beyond the rest of the lips, nevertheless bear fine tuberculiform or digitiform processes (figs. 2, 3) which correspond with the conchular lobes of other forms. Two of these processes form a pair lying one on either side of the more dorsal portion of the siphonoglyph opening, and the three others are situated more ventrally, the median one being in the sagittal plane of the body, opposite the bottom of the siphonoglyph. In three individuals examined, of different sizes, I found no variation in the form or arrangement of these conchular processes, and would therefore conclude that this is their final adult arrangement.

*Size*.—The height of the column, measured in individuals preserved in formalin, was in the larger forms about 2.0 cm., the diameter at about the middle being about 0.9 cm., and at the limbus 0.6 cm. The length of the tentacles was 0.4 cm.

*Colour*.—Examples preserved in formalin retain a considerable amount of the original coloration, and from these it is possible to state that the general colour of the column is a more or less intense brownish red. In some cases it is distributed over the entire extent of the column and in others it is limited to the distal portion, the proximal or basal part being almost colourless. A closer examination shows that the pigment is not uniformly distributed throughout the area in which it occurs, but presents the appearance of a brownish red ground-colour upon which are scattered numerous minute dots of a paler shade, these

representing the small elevations already described as scattered over the entire surface of the column. The tentacles seem to have been of a paler colour than the upper part of the column and marked by four or five rings of a more or less intense brownish red (fig. 2). The conchular processes seem to have been of the deeper shade, with paler apices.

*Structure.*—The column mesogloea is much thicker than the ectoderm and is of a finely fibrillar structure, cells being scattered among the fibrils. There are no ectodermal muscles, but associated with the presence of ectodermal gland-cells there is a well-defined layer of nerve-fibres. The adhesive organs appear in sections as elevated areas of the ectoderm, composed of slender cells considerably longer than those of the adjacent ectoderm; the areas contain no gland-cells and, consequently, appear much paler than the general ectoderm in stained preparations. In structure, therefore, the organs differ from typical verrucae only in being elevations of the surface instead of depressions. The endodermal musculature is supported on short simple processes, and towards the distal portion of the column it becomes weaker, the cells being arranged in an almost simple layer, and there is no indication of a sphincter.

The musculature of the tentacles and disk is very moderately developed, and there are no muscle-fibres on either the ectodermal or endodermal surface of the stomatodæum. The structure of the siphonoglyph is quite characteristic. Its ectoderm is much higher than that of the rest of the stomatodæum and destitute of gland-cells. The surface bears very numerous strong cilia and is provided with a distinct cuticular layer, beneath which the nuclei of the cells are arranged in very many layers, the basal portion of the epithelium containing but few, and appearing as if composed of a very fine reticulum, which is traversed by a band of nerve-fibres. The endoderm is also much higher than it is over the rest of the stomatodæum and its basal portion is also reticular in structure, though somewhat coarser than the ectoderm. The mesogloea also differs from that of the general stomatodæum, its ground-substance being almost homogeneous and assuming a clear blue tint with hæmatoxylin-erythrosin, while elsewhere the colour is decidedly violet. The fusion of the lips, mentioned above, is merely an epithelial union; indeed, it appears to be due to adhesion of the cuticular layers of the two adjacent surfaces.

The mesenteries are arranged in ten pairs, six of which are perfect, the remaining four pairs occupying the lateral and sulco-lateral interspaces. Of the perfect mesenteries, two pairs are directives, and all have well-developed diffuse muscle-pennons (fig. 4) consisting of strong though but slightly branched lamellæ. A well-marked parieto-basilar muscle is also present forming usually a slight fold. The reproductive cells could not be distinguished in the individuals examined, but the endoderm of the mesenteries in the region proximal to the

mesenterial filament is greatly thickened and very granular, as if from the presence of ingested food-material. The eight imperfect mesenteries are destitute of mesenterial filaments and, indeed, represent only the muscular portion of the perfect mesenteries. Their muscle-processes are but few in number and they do not possess any distinct parieto-basilar muscle. There is no difference in the development of the various perfect mesenteries such as Fautot has described for *P. hastata*; all are provided with mesenterial filaments and are alike in all particulars.

The first description of a form that may definitely be assigned to the genus *Peachia* is that furnished by Reid (1848) of a species washed ashore in the Bay of St. Andrews and named *Actinia cylindrica*. This name had, however, already been employed by Renier (1804) for *Cerianthus membranaceus*, and has therefore given place to the term *Peachia hastata*, proposed by Gosse (1855) for a form with which Reid's species is evidently identical. In the following year Koren and Danielssen described under the name *Siphonactinia boeckii* a form that is certainly congeneric with the *Peachia* of Gosse, and that author in 1860 described two additional members of the genus, *P. undata* and *P. triphylla*. No further additions to the list of species were made until 1879, when Hutton described as *P. carnea* a form cast up on the beach at Dunedin, New Zealand; a little later Andres (1883) described as *Siphonactinia tricapitata* a form from Naples that he had originally (1881) considered identical with Gosse's *P. triphylla*, and in 1893 I described *P. koreni* from off the coast of the Argentine Republic. There seems to be no room for doubt as to the distinctness of *P. quinquecapitata* from *P. hastata*: the form of the conchula, the equality of all the perfect mesenteries, and the feeble development of the longitudinal musculature of the imperfect ones furnish sufficient bases for their separation, independently of their coloration and geographical distribution. *P. koreni*, with only eight tentacles and a simple conchula, may also be regarded as distinct, and although the description of *P. carnea* is very incomplete, its geographical distribution is *prima facie* evidence of its distinctness also.

With regard to the remaining four species, all of which are European, the evidence is not so clear, since no anatomical data concerning them are available. *P. undata*, from the Channel Islands, is believed by Haddon (1889) and G. Y. & A. F. Dixon (1891) to be merely a young example of *P. hastata*, its conchula resembling that of immature examples of the latter species. *P. triphylla*, also from the Channel Islands and the Firth of Clyde (Robertson, 1869, 1875), on the other hand, has a conchula composed of three lamellar processes, and in this resembles *P. boeckii*; the latter, however, bearing the lamellæ upon the summit of a tubular prolongation of the siphonoglyph, whereas in Gosse's figure of *P. triphylla* they are represented as sessile. The difference may, however, be due to a difference in contraction,



and it is not improbable that the two forms are identical. It must be noted, however, that Faurot (1895) identifies *P. boeckii* with *P. hastata*, and until anatomical data are furnished it will be well to regard it as a distinct form. Finally, in the Mediterranean *P. tricapitata* the conchula is composed of tubercles; and while the correctness of its original identification by Andres (1881) with *P. triphylla* must still be regarded as a possibility, it seems advisable for the present to regard it as a good species.

A provisional arrangement of the known species of *Peachia* may then be stated thus:—

Tentacles 12.

Conchular lobes 6-20, irregular .....	<i>P. hastata</i> .
Conchular lobes 3, lamellar,	
sessile .....	<i>P. triphylla</i> .
borne on tubular prolongation of siphonoglyph. ....	<i>P. boeckii</i> .
Conchular lobes tuberculiform,	
three in number .....	<i>P. tricapitata</i> .
five in number .....	<i>P. quinquecapitata</i> .
? .....	<i>P. carnea</i> .
Tentacles 8 .....	<i>P. koreni</i> .

*BICIDIUM EQUOREÆ*, sp. n. (Pl. XCVIII. figs. 5-7.)

This form is not uncommon as a parasite upon the bell of the Leptomedusa *Æquorea forskalii*, which is of very common occurrence in the waters of British Columbia. The column (fig. 5) has a rounded base, is somewhat conical or urn-shaped and wrinkled transversely by contraction in examples preserved in formalin. Proximally it usually shows some faint longitudinal grooves which mark the lines of insertion of mesenteries, but no signs of verrucæ or other adhesive organs could be seen. The margin, which is indistinct, is occupied by a single series of twelve short and obtuse tentacles. The mouth (fig. 6) is usually widely expanded, so as to completely hide the disk, and shows a single siphonoglyph; no conchula was present.

*Size*.—Length about 7 mm., greatest diameter 4 mm.

*Colour*.—There was no trace of colour in any of the examples seen.

*Structure*.—The column mesogloea is thinner than either the ectoderm or endoderm and has a homogeneous or finely fibrillar structure, cells being scattered throughout the ground-substance. The ectoderm is of uniform structure throughout its entire extent, no verrucal areas being distinguishable. There are no ectodermal muscle-fibres, and those of the endodermal surface are arranged in a simple layer, there being no mesogloéal lamellæ for their support and no indications of a sphincter muscle. The musculature of the tentacles is also very feeble, the ectodermal fibres being arranged in a single uniform layer, while the endodermal ones are hardly distinguishable.

The single siphonoglyph is prolonged somewhat below the level

of the rest of the stomatodæum and forms a well-marked deep groove, whose endoderm is much higher than that of the rest of the stomatodæum, although it does not present a reticular formation such as occurs in *Peachia quinquecapitata*. There are six pairs of mesenteries, all of which are perfect and all possess mesenterial filaments; no indications of additional mesenteries of the second cycle were to be found. Two of the six pairs were directives. The longitudinal musculature (fig. 7) formed a low pennon extending throughout the entire muscular area of the mesentery, the supporting lamellæ being palisade-like in their arrangement, and is higher than the endoderm that covered them. No parieto-basilar muscle was present in my preparations, which did not, however, include the most proximal portion of the column.

A number of immature Actinians, a list of which has been given by Haddon (1887), have been described as parasites in various species of Medusæ, and all present structural features sufficiently similar to suggest that they are generically identical with one another and with the form described above. They have been assigned in part to the genus *Halcampa* and in part to *Peachia*, but none of these has yet been actually shown to transform into the one or the other of these genera, and until the adult condition is definitely known it seems well to retain for them the genus *Bicidium* established by L. Agassiz (1859), recognizing, however, that this is but provisional and that the forms assigned to it are larval or at least immature.

The evidence furnished by the structure, although not conclusive, does however give some indications of the probable position of the adult form and, I believe, points towards the genus *Peachia*, rather than to *Halcampa*. Differences between the two genera that are pertinent to this question are to be found in the presence of a conchula in *Peachia* and its absence in *Halcampa*; in the single deep siphonoglyph of *Peachia* as compared with the two shallow ones of *Halcampa*; and in the somewhat diffuse form of the muscle pennons in *Peachia* as compared with the compact and circumscribed ones of *Halcampe*. The first of these differences is not apparent in all species of *Bicidium*, the conchula probably being late in its development, but the other characteristics are constant in all known forms whose anatomy has been recorded.

Since Haddon (1887) reviewed the various species of *Bicidium* some additions have been made to our knowledge of them, and in support of my contention as to their affinities to *Peachia* rather than to *Halcampe*, a reconsideration of them may not be amiss. The absence of a conchula in *B. æquoreæ* is, it is true, opposed to its reference to *Peachia*, but, as has been pointed out, this structure may very well be late in developing, and in the nature of the siphonoglyph and the muscle pennons the similarity to that form and the difference from *Halcampe* are pronounced.

The occurrence of *P. quinquecapitata* in the same locality is also suggestive, but the differences between the two forms are too marked to warrant their identification, although it is not improbable that these differences are due to age rather than specific differences.

The structure of *Actinia clavus* of Quoy and Gaimard (1833), recently studied by Pax (1912), shows, I believe, that it must be considered congeneric with *B. æquorea*, although Pax refers it to the genus *Halcampa*. As in the British Columbian species, there are no indications of a conchula; but again, the form of the siphonoglyph and the muscle pennons suggest *Peachia* rather than *Halcampa*, and until further evidence as to its exact position is available, it would seem well that it should be known as *Bicidium clavus*.\*

The evidence as to the affinities of *B. parasiticum* is more definite. It was first described by L. Agassiz (1859) from *Cyanea arctica* and later by Verrill (1864), who showed that it possessed a well-marked trilobed conchula, and, still later (1866), assigned it to the genus *Peachia*. Preparations that I have of this species show it to have a striking general similarity to *B. æquorea*, the mesenteries being twelve in number, all perfect and all bearing mesenterial filaments, and the siphonoglyph single and deep. The muscle pennons also are of the same diffuse type, but the lamellæ (fig. 8) are not arranged in the manner of a palisade, but are decidedly branched in a dendritic manner so that they present an appearance of being arranged in groups. It is to be noted that Verrill (1874) mentions the capture of two very large examples of this species, imbedded in gravel at low-water mark at Eastport, Maine; he does not, however, give any anatomical data concerning them, and until it is definitely known that the form develops the four pairs of secondary mesenteries (zygocnemes), it seems advisable to allow it to remain in the genus *Bicidium*.

The form which F. Müller (1860) described very completely as *Philomedusa vogtii* is also undoubtedly a *Bicidium*. It occurred upon the medusæ *Olindias* and *Chrysaora* and was provided with a trilobed conchula, twelve tentacles, twelve mesenteries, all of which were perfect and furnished with mesenterial filaments, and had a single siphonoglyph. The form described by Graeffe (1884)

\* The observations of Pax make it quite certain that R. Hertwig (1882) was in error in identifying a *Halcampa* from the Kerguelen Islands with Quoy and Gaimard's species. The possibility of Hertwig's forms being young examples of Studer's *Edwardsia kerguelensis*, which Kwietniewski (1896) has shown to be a Halcampid, should not be lost sight of, although the differences in the descriptions as they stand are too great to permit of a definite identification. Furthermore, the contention of Pax that the *H. clavus* of Tizard and Murray (1881) and Appellöf (1897) is distinct from that described by Hertwig is undoubtedly correct, but since the forms so named by Appellöf were the actual types of Danielssen's *Halcampoides abyssorum*, it is difficult to understand the necessity for the new name, *septentrioalis*, that Pax bestows upon them.

as *Halcampa medusophila*, occurring on various medusæ (*Tima*, *Oetorchis*, and *Egorea*) is probably identical with Müller's species, the absence of a conchula being probably due to its greater immaturity.

In 1860 Wright described as *Peachia fultoni*\* a form that he found parasitic on a species of *Thaumantias* (*Phialidium*?), later (1861) changing its name to *Halcampa fultoni*. This is probably the same as the form described by Haddon (1887), and erroneously, as has been pointed out by Carlgren (1904), regarded by that author as the larva of *Halcampa chrysanthellum*. In 1887, McIntosh recorded the occurrence of actinian larvæ on various Thaumantiad medusæ occurring at St. Andrews, identifying them as the young of *P. hastata*, an opinion in which Haddon (1888) concurred after an examination of their structure, still maintaining, however, their distinctness from the examples previously described as the young of *H. chrysanthellum*. They possessed eight tentacles and eight large mesenteries together with four smaller deuteroecemic ones. It may be that Haddon is correct in regarding the two forms he examined as distinct species, but even if so it seems clear that they are to be referred to the same genus, and since it is still uncertain that they actually do develop into *Peachia*, it will be preferable to place them in *Bicidium*.

Finally, Dendy (1888) has described from medusæ obtained at Port Philip a parasitic actinian with twelve tentacles, within which there was "an inner circle of 12 cushion-like swellings," which in older individuals become saccular outgrowths. It is not possible to ascertain from Dendy's account, whether or not these outgrowths represent a conchula, and the exact affinities of the form must remain doubtful, although with a probability that it represents a *Peachia*†.

The available evidence seems, accordingly, to point strongly in favour of these various medusophilous forms being young stages in the development of *Peachia* rather than *Halcampa*, but a direct linking up of the immature examples of *Bicidium* with their respective adults is necessary to settle the question.

\* Some confusion exists in the references to the literature of this species. Andres (1883) gives the date of its first description as 1859 and as references the Proceedings of the Physical Society of Edinburgh, vol. ii. 1859, and the New Edinburgh Philosophical Journal, vol. xii. 1860. Haddon (1887) repeats the latter reference but substitutes for the former, Proceedings of the Royal Society of Edinburgh, vol. ii. 1860. There is no paper in the Proceedings of the Royal Society of Edinburgh by Wright referring to this species, and the date of vol. ii. of the Proceedings of the Royal Physical Society of Edinburgh, which does contain such a paper, is 1861 and not 1859. The reference to the Edinburgh New Philosophical Journal (this being its correct title) should read "New Series, vol. xii. 1860."

† Carlgren (1904) mentions, without descriptions or names, two additional forms that should probably be referred to this genus, one occurring in the medusa *Eutimalphes indicans* on the Swedish coast and the other on a large medusa from Valparaiso.

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## EXPLANATION OF PLATE XCVIII.

Fig. 1. *Peachia quinquecapitata*. Nat. size.

2. Oral view of *P. quinquecapitata* expanded.  $\times 2^1$

3. Oral view of partially contracted individual of *P. quinquecapitata*, showing arrangement of conchular lobes.

4. Transverse sections of mesenteries of *P. quinquecapitata*.

5. Side view of individual of *Bicidium æquorea*.  $\times 4$ .

6. Oral surface of *B. æquorea*.  $\times 4$ .

7. Transverse sections of mesenteries of *B. æquorea*.

8. Transverse sections of mesenteries of *B. parasiticum*.

57. Sponges in Waterworks. By W. N. PARKER, Ph.D., F.Z.S., Professor of Zoology, University College, Cardiff.

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Some three or four years ago I received through my colleague, Dr. Schölberg, some specimens of a branched, yellowish-brown organism which had been found growing in some of the pipes at the Cardiff Waterworks, and which proved to be very fine examples of *Spongilla lacustris*. Subsequently I learnt that there had been an extensive growth of this sponge in the pipes leading to one of the series of filter-beds, which had caused much trouble and difficulty; and that, although the growth had apparently disappeared for a time after treatment with sulphate of copper, it, as I expected, soon appeared again, and became as flourishing as ever. In the summer of 1911 the growth was so extensive as to cause anxiety, not only as regards reducing the flow in the pipes, but also on account of the unpleasant odour which had been noticed in the water, due doubtless to the living sponge as well as to its decomposition. In December of the same year I was requested by the Waterworks Engineer, Mr. C. H. Priestley, to report on the matter to the Waterworks Committee; and now that the treatment I subsequently proposed has—at any rate for the present—been successful, I have the permission of the Committee to publish an account of our experiences. I should like to express my indebtedness to Mr. Priestley and his staff for their cooperation and for giving me every facility in prosecuting the enquiry; I have also to thank Dr. Kemna, of Antwerp, Dr. Harmer, Mr. Kirkpatrick, and Professor Minchin for valuable information given at the beginning of the investigation.

Although sponges of various species have been recorded at numerous other Waterworks\*, they do not appear to have been the chief source of trouble, as at Cardiff.

The interesting subject of the fauna of Waterworks has quite recently been so fully dealt with by Dr. Harmer in these "Proceedings" (1913, p. 426), that it is unnecessary for me

\* *E. g.* at Boston, Mass. (Bowerbank, Proc. Zool. Soc. 1863, & Potts, Acad. Nat. Sci. Philadelphia, 1881, 1882, and 1887); Hamburg (Kraepelin, Abh. Naturwiss. Ver. Hamburg, 1886); Torquay (Chapman, "Animal Growths in Water-pipes," Transactions of the Institute of Water Engineers, 1913, & Kirkpatrick—see Harmer, P. Z. S. 1913, p. 436); and Aberdeen (Kirkpatrick, *loc. cit.* p. 439).

to refer in detail to the history and literature of the subject. Dr. Harmer's account of the difficulties which have recently occurred in various English Waterworks owing to the presence of Polyzoa, shows the importance of biological investigation in dealing with such cases, as was pointed out in this country by Professor Hickson in his presidential address to Section D of the British Association at Southport in 1903.

The Cardiff district is supplied with excellent soft water from the Taff Fawr reservoirs in Brecknockshire, midway between Merthyr and Brecon. From these higher reservoirs the water is conducted by conduits into various other storage-reservoirs at a lower level, in the near neighbourhood of Cardiff, and from those into filter-beds: the latter, of course, prevent the access of organic particles and spicules into the service-pipes supplied from them. The sponge had hitherto only been found in the pipes leading to certain of the filters on the northern border of Cardiff known as the "Heath" filters, from which the greater part of the city is supplied. The water to these filters comes from two storage-reservoirs, at Llanishen and Lisvane, situated about a mile farther north. Careful examination has so far not revealed any trace of the sponge in other parts of the system, which therefore I need not describe further here\*.

The water from Llanishen reservoir passes through metal screens with fine meshes, so as to strain off all but minute solid particles, into a valve-shaft from which it is conducted by underground pipes to a valve-chamber at the "Heath." It is then again screened before flowing into a 3-ft. pipe, with which lateral pipes are connected ending in bell-mouths, one to each of the six filter-beds.

The chief trouble occurred in this pipe, which was thickly lined with a luxurious growth of the sponge, consisting of dense incrustations giving off numerous finger-like processes which branched and branched again, and some of which reached a length of 8 inches or more, frequently showing concrescence†. Other growths were found in the valve-chamber and screen-chamber, in the corners and crevices of which it was not easy to get access to them.

On visiting the "Heath" on December 12th, 1911, the sponge, packed with gemmules, showed no signs of dying down for the winter, and it appeared to me that had it been desired to cultivate the organism, probably no better plan could have been devised than that furnished by the water-chambers and pipes

\* For further details with regard to the Cardiff Waterworks, see a paper by C. H. Priestley, M.Inst.C.E., on the "Development of the Cardiff Water Supply," read at the Sessional meeting of the Royal Sanitary Institute at Cardiff on April 12th, 1912; also a description of the Waterworks by the same author issued from the Cardiff Waterworks Engineer's Office, 1908.

† Cf. figures by Bowerbank, "A Monograph of the British Spongiadae," Ray Society, 1864-1882; and Johnston, "A History of British Sponges and Lithophytes (Corallines)," London, Edinburgh, and Dublin, 1882.



(*cf.* Kraepelin, *loc. cit.*). It can grow as well in the dark, without zoochlorellæ, as in the light; and being effectively protected from frost and other adverse conditions, it seemed possible that it might continue alive during the whole winter. On the same day, we made a cursory examination at Llanishen and Lisvane, with no result; but on the following day, the reservoir-keeper, after emptying the valve-shaft at Llanishen, found a considerable growth at a depth of between 10 and 20 feet.

Since then, a careful look-out has been kept for the sponge throughout the entire system, but there has been no positive evidence of its occurrence in other parts, either in the open or in the underground pipes.

The two most important problems which presented themselves were—the destruction of the sponge in the infected area, and the prevention of re-infection throughout the whole system. As regards the latter, the only sound method would be the introduction of pre-filtration through sand, so as to starve the sponge by preventing the microscopic organisms (on which it and other “microphagous” organisms which might at any time appear depend for their nutriment) from passing into the pipes and reservoirs (*cf.* Kemna, quoted by Harmer on p. 432), as well as to keep out larvæ and gemmules. This method would take a long time to carry out and entail considerable expense; moreover, it would not be effective unless it could be adopted at the lower reservoirs (where there are difficulties as regards level) as well as the higher ones, as there would be a reappearance of organisms in them. As the matter was urgent, I therefore felt it would be better to confine attention at first to the destruction of the organism in the infected area and the prevention of its regeneration and of reinfection by the gemmules.

Treatment with any destroying agent except such as would be dangerous to human life would be ineffective if applied to the adult sponge, as it would not destroy the myriads of gemmules protected by their resistant coats. It was therefore necessary in the first instance to make a periodical examination of the sponge for a year or more, so as to ascertain (1) whether sexual reproduction occurred, (2) when the gemmules germinated, and (3) whether the adult growth perished partially or entirely during the course of the winter\*.

An examination of specimens at various times of the year has so far revealed no larvæ or any signs of sexual reproduction; but the enormous production of gemmules throughout the crusts and branches is quite sufficient to start new growths in any part to which the gemmules could gain access. There can be no doubt that a sexual stage is unnecessary for the reproduction of the sponge from year to year.

\* *Cf.* Marshall (SB. Naturf. Gesellsch., Leipzig, 1884, & Journ. Roy. Micros. Soc. v. 1885); Weltner (Archiv f. Entwicklungsmechanik, Bd. xxxiii. Heft 3 u. 4).

On visiting the "Heath" and Llanishen on February 3rd, 1912, when the filter-beds were covered with ice  $1\frac{1}{2}$  ins. thick, we found that the adult growth was dying down, but that it was still closely packed with gemmules, some of which had begun to germinate and start new growths among the old. On March 23rd gemmation had proceeded further, new growths being abundant, and I suggested that in the course of the spring the pipes and chambers should be scraped and treated with strong brine, so applied as to reach any small spaces and crevices in which gemmules could lodge, and thus to attack the sponge when it was least capable of resistance. This was done on May 2nd, and with the sponge were removed a large quantity of iron corrosive nodules—another trial to the Water Engineer, referred to by Harmer on pp. 430, 437, & 438 of his paper; the brine was then washed out through a bye-pass. The result was apparently satisfactory, but in the course of the summer a few small new growths were observed by the Foreman: they were very much less abundant than in the previous summer, and no smell had been noticed since the treatment. An examination on September 24th showed that these comparatively few young incrusting sponges had not yet given rise to any outgrowths, and that they contained no gemmules: they were in all probability due to a few gemmules which had not germinated when the treatment was carried out. I therefore suggested a second application of brine. By November 14th, when this was done, the growths had increased in size considerably, but apparently no gemmules had been formed. Instead of leaving the pipes empty for only a few hours, as on the previous occasion, it was possible this time to give them three days before being again used, and since then no trace of the sponge has been seen.

It is interesting to note that no Polyzoa were found, but that a number of colourless Hydreæ like those described by Kraepelin at Hamburg were obtained by the reservoir-keeper from the bottom of the valve-shaft at Llanishen on May 25th; unfortunately these were all dead by the time they reached me\*.

\* Since the above was written, a few young sponge-growths were again observed and at once destroyed. Colonies of *Cristatella*, with numerous statoblasts, had also appeared: fortunately this is not one of the "moss"-forming Polyzoa. (Oct. 25th, 1913.)





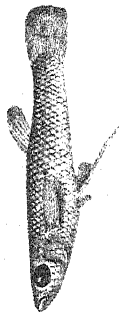
1.



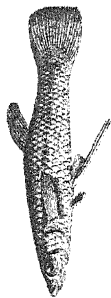
5.



2.



4.



6.



3.



7.

A.H. Searle del. et lith.

Both imp.

1, 2. GAMBUSIA OLIGOSTICTA. 3, 4. G. WRAYI.  
5, 6. G. GRACILIOR. 7. G. DOMINICENSIS.





2.



1.



4.



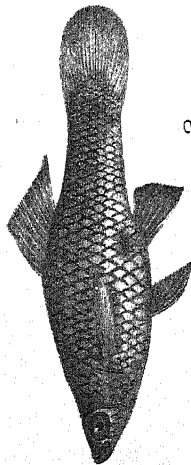
8.



6.



7.



3.



5.

A.H. Searle del. et lith.

Huth imp.

1, 2. POECILIA PICTA. 3, 4. POECILIOPSIS ISTHMENSIS.

5, 6. PHALLOCEROS CAUDOMACULATUS. 7, 8. PHALLOPTYCHUS JANUARIUS.





1.



5.



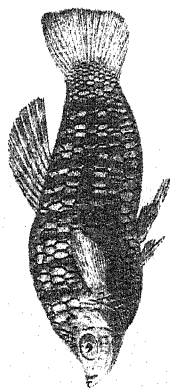
3.



4.



6.



2.



7.

A.H. Seale del. et lith.

Hutch. imp.

1, 2. LIMIA NIGROFASCIATA. 3, 4. L. HETERANDRIA.  
5. L. ARNOLDI. 6. L. CAUDOFASCIATA. 7. L. ORNATA.



# 58. A Revision of the Cyprinodont Fishes of the Subfamily Pœciliinæ. By C. TATE REGAN, M.A., F.Z.S.

[Received October 11, 1913; Read November 11, 1913.]

(Plates XCIX.-CI.\* and Text-figures 168-173.)

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The Pœciliinæ are viviparous Cyprinodonts in which the anal fin of the male is advanced and modified into an intromittent organ. They are American, ranging from Carolina to Argentina and from Arizona to Ecuador; many of the species live in the sea as well as in fresh water. Most of the species are quite small, two or three inches long; the giant of the group, *Belonesox belizanus*, attains a length of eight inches. In some forms the males are much smaller than the females, and the adult male of *Heterandria formosa*, 15 to 20 mm. long, is one of the smallest fishes known; in several species males are rather scarce.

In Günther's classification (Cat. Fish. vol. vi.) the Cyprinodonts were divided into Carnivoræ, with the intestine short or but little convoluted and the bones of the lower jaw firmly united, and Limnophagæ, with the intestine long and convoluted and the bones of the lower jaw loosely connected. It is now known that both types occur in two distinct subfamilies, Characodontinæ and Pœciliinæ, and there is good evidence that in the latter the

\* For explanation of the Plates see p. 1018.

limnophagous structure has been evolved three or four times independently.

The intromittent organ is freely movable and is supported internally by bony stays, 2 to 5 in number, that project downwards and forwards from the bridges that connect the parapophyses of the posterior præcaudal vertebræ. It is formed by the prolongation of the third, fourth, and fifth anal rays, the first and last of which are stout and are more or less expanded transversely so as to margin a groove on one side or the other, or they may even meet so as to form a tube. The urogenital orifice is directly in front of the base of the fin, and may often be covered by the pelvic fins, which, doubtless, help to conduct the seminal fluid into the groove, or in certain forms where the pelvic fins of the male are considerably enlarged they may be closely applied to the intromittent organ, converting the grooves into closed tubes. The distal segments of the prolonged rays may be variously modified into spines, hooks, barbs, etc., which may help to retain the organ in position during coition.

The differences in structure of the intromittent organ are of great systematic importance; hitherto they have been almost neglected, except by Eigenmann (Proc. U.S. Nat. Mus. xxxii. 1907, p. 425), who has described them in the genera *Lebistes*, *Girardinus*, *Glaridichthys*, *Phalloceros*, and *Phalloptychus* \*.

Many of the species eat Mosquito larvæ, and the "Millions" fish (*Lebistes reticulatus*) has been introduced into many countries in the hope that it will check malarial fever†. On account of their small size, pretty appearance, and interesting habits the *Peciliinæ* are great favourites with European aquarium-lovers, especially in Germany; several of the new species described below have been sent to me by my valued correspondents in Hamburg, Herr J. P. Arnold and Herr A. Rachow, as newly imported aquarium-fishes. In the German aquarium-journals and in two booklets by Stansch (Die lebendgebärende Zalmfarkfen, Leipzig, Wenzel, 1910, 1911) have appeared many accounts of the habits of different species: from these one gathers that the broods follow each other at intervals of only a few weeks, but that the number of young varies greatly according to the species; thus a pair of *Pecilia parva* had broods of 8, 11, and 10 at intervals of four weeks, but in *P. vivipara* 124 were counted in a single brood. The new-born young are usually from 5 to 10 mm. long and grow rapidly, in many species attaining sexual maturity in about three months. The breeding-habits are of great interest: in species where the males are brilliantly ornamented (*Mollienisia*, *Xiphophorus*, *Pecilia branneri*) they dart about displaying their beauty; in these and in related forms the females appear to encourage their advances, but in others they are quite shy and their mates have to exercise cunning to get near them. It

\* Some additional figures are given by Langer in a paper on the morphology of these fishes, just published (Morph. Jahrb. xlvii.).

† See P. Z. S. 1910, p. 146; 1912, p. 906.

is of some interest to note that in *Pecilia* and related genera the females welcome the attentions of the males and the intromittent organ is quite short, but as in *Gambusia* and *Phalloceros* the females try to make the males keep their distance it is much longer.

*Synopsis of the Genera* \*.

- I. Lower edge of caudal peduncle sharp, without a median series of scales; bones of lower jaw firmly united; teeth conical or villiform.
  - Body rather deep; pelvic fins well developed, behind base of pectorals; anal fin of male without long appendages ..... 1. *Alfara*.
  - Body elongate; pelvic fins absent in female, minute and below gill-openings in male; anal fin of male ending in a pair of long appendages with spine-like processes ..... 2. *Tomenrus*.
- II. Lower edge of caudal peduncle rounded or obtuse, with median series of scales.
  - A. Pelvic fins similar in both sexes.
    1. First produced ray of anal fin of male without long processes or appendages.
      - a. Third and posterior branch of second produced ray of anal fin of male each ending in a retrorse spine or hook.
        - Jaws not produced; teeth conical or villiform; anal fin of male with distal part of first produced ray serrated, the terminal serrations directed towards its tip; third produced ray and posterior branch of second each ending in a retrorse hook. Dorsal 6-12; origin behind that of anal ..... 3. *Gambusia*.
        - Jaws produced; teeth slender, pointed, depressible; anal fin of male with terminal segments of first produced ray not forming serrations; third produced ray and posterior branch of second each ending in a retrorse spine ..... 4. *Belonesox*.
      - b. Third and posterior branch of second produced rays of anal fin of male not bearing retrorse hooks or spines.
        - a. Anal fin of male ending in a more or less distinct antrorse hook, the anterior branch of the second produced ray curved forward.
          - \* Mouth moderate, with distinct lateral cleft; teeth conical or villiform.
            - † Dorsal 7-12; origin behind that of anal.
              - Extremity of anal fin of male supported equally by third and anterior branch of second produced rays ..... 5. *Priapichthys*.
              - Extremity of anal fin of male supported equally by first and anterior branch of second produced rays ..... 6. *Priapella*.
            - †† Dorsal 11-17; origin in advance of that of anal; extremity of male anal fin a strong hook formed by the unsegmented end of the anterior branch of the second produced ray ..... 7. *Pseudoxiphophorus*.
          - \*\* Mouth small, without distinct lateral cleft; hook at end of anal fin of male formed by anterior branch of second produced ray.

\* The differences in the structure of the male intromittent organ used in this synopsis are illustrated in text-figs. 168, 169 (genera 1 to 4 and 11), 170 (genera 5 to 10), 171 (genera 10 and 13), 172 (genera 14 to 22), and 173 (genera 23 to 26).

- Teeth somewhat compressed, pointed; anal fin of male with first produced ray not serrated, third longer than posterior branch of second ..... 8. *Heterandria*.
- Teeth broad incisors; anal fin of male with first produced ray serrated not far from tip, third shorter than posterior branch of second ..... 9. *Pseudopocilia*.
- \*\*\* Mouth small, transverse; teeth movable, oar-shaped. Extremity of anal fin of male supported equally by first and anterior branch of second produced rays; first not serrated ..... 10. *Pociliopsis*.
- β. Anal fin of male short, ending in a small retrorse hook formed by second and third produced rays; teeth conical or villiform ..... 11. *Brachyrhaphis*.
- γ. Anal fin of male long and slender, not ending in an antrorse hook.
- Bones of lower jaw firmly united; teeth conical or villiform, fixed ..... 12. *Leptorhaphis*.
- Bones of lower jaw loosely connected; teeth more or less expanded and compressed, movable ..... 13. *Phalloptychus*.
2. First produced ray of anal fin of male ending in an antrorse appendage; mouth small, but bones of lower jaw rather firmly joined.
- Appendage forked, each fork antler-like; teeth oar-shaped ..... 14. *Phalloceros*.
- Appendage not forked, long, doubly curved, pointed; teeth chisel-shaped ..... 15. *Cnesteron*.
3. First produced ray of anal fin of male bearing a pair of curved horn-like processes not far from its end.
- a. Bones of lower jaw firmly united.
- Teeth chisel-shaped; outer series close-set ..... 16. *Glaridichthys*.
- Teeth spear-shaped; outer series spaced ..... 17. *Torus*.
- b. Bones of lower jaw loosely connected; teeth movable ..... 18. *Girardinus*.
- B. Pelvic fins enlarged in the males, the second ray longest.
1. Bones of lower jaw firmly united; outer series of teeth slender, pointed ..... 19. *Pamphorichthys*.
2. Bones of lower jaw rather firmly united; outer series of teeth broad incisors ..... 20. *Pamphoria*.
3. Bones of lower jaw loosely connected; outer series of teeth slender, curved, oar- or spoon-shaped; intromittent organ short.
- a. Extremity of intromittent organ unprotected; first produced ray with terminal hook and strong subterminal serrations; anterior branch of second hooked forward; posterior branch of second with distal segments produced into serrations beyond extremity of third.
- Third produced ray without hook; anterior branch of second unsegmented distally; caudal similar in both sexes. Dorsal 9-11 ..... 21. *Platyptæcilus*.
- Third produced ray ending in a retrorse hook; anterior branch of second segmented throughout; caudal of male with lower rays produced into a long pointed appendage. Dorsal 11-15 ..... 22. *Xiphophorus*.
- b. Extremity of intromittent organ protected by a hood of thick skin that can be slipped off frontwards, being attached only at its base to the first prolonged ray.
- α. First prolonged ray tapering evenly, sharply serrated distally.

- First prolonged ray without antrorse spine: last without terminal process ..... 23. *Pæcilia*.  
 First prolonged ray without antrorse spine; end of last bearing a pair of processes directed outwards and towards the base of the fin ..... 24. *Lebistes*.  
 First prolonged ray bearing a small antrorse spine at or near its end; last with processes as in *Lebistes* ..... 25. *Mollienisia*.  
      $\beta$ . First prolonged ray becoming abruptly slender at some distance from end, not sharply serrated, bearing a small antrorse spine at or near its end; last prolonged ray without terminal processes ..... 26. *Limia*.

## 1. ALFARO Meek, 1912.

*Petalosoma* (non Lewis) Regan, Ann. Mag. Nat. Hist. (8) ii. 1908, p. 462.

Alfaro Meek, Field Mus. Publ. Zool. x., Sept. 1912, p. 72.

*Petalurichthys* Regan, Ann. Mag. Nat. Hist. (8) x., Nov. 1912, p. 494.

This genus resembles *Gambusia*, except for the sharp lower edge of the tail. The intromittent organ (text-fig. 169 F, p. 990) is simple in structure, and the pelvic fins are enlarged in the male.

## 1. ALFARO CULTRATUS.

*Petalosoma cultratum* Regan, Ann. Mag. Nat. Hist. (8) ii. 1908, p. 462.

Alfaro *acutiventralis* Meek, Field Mus. Publ., Zool. x. 1912, p. 72.

Depth  $3\frac{1}{2}$  in the length. Dorsal 7-8; when laid back nearly reaching caudal. Anal 9-10, in advance of dorsal. 32 to 35 scales in a longitudinal series. Total length 45 to 90 mm.

Costa Rica.

## 2. ALFARO AMAZONUM.

*Petalosoma amazonum* Regan, Ann. Mag. Nat. Hist. (8) viii. 1911, p. 659, figs.

Depth  $3\frac{2}{3}$  in the length. Dorsal 8-9, when laid back not reaching caudal. Anal 10, in advance of dorsal. 33 or 34 scales in a longitudinal series. Total length 35 to 51 mm.

R. Amazon at Obidos.

## 2. TOMEURUS Eigenm., 1909.

Ann. Carnegie Mus. vi. p. 53.

## TOMEURUS GRACILIS.

Eigenm. l. c. and Mem. Carnegie Mus. v. 1912, p. 460, pl. lxx. figs. 7-8.

British Guiana.

## 3. GAMBUSIA Poey, 1855\*.

Mem. i. p. 382.

*Gambusia* (part.) Günth. Cat. Fish. vi. p. 333 (1866); Garman,

\* *G. picturata* Poey ('Synopsis,' p. 410, 1868) is a doubtful species of uncertain position.

Mem. Mus. Comp. Zool. xix. 1895, p. 82; Regan, Biol. Centr.-Amer., Pisces, p. 93 (1907).

*Parayambusia* Meek, Publ. Columbian Mus., Zool. v. 1904, p. 133.

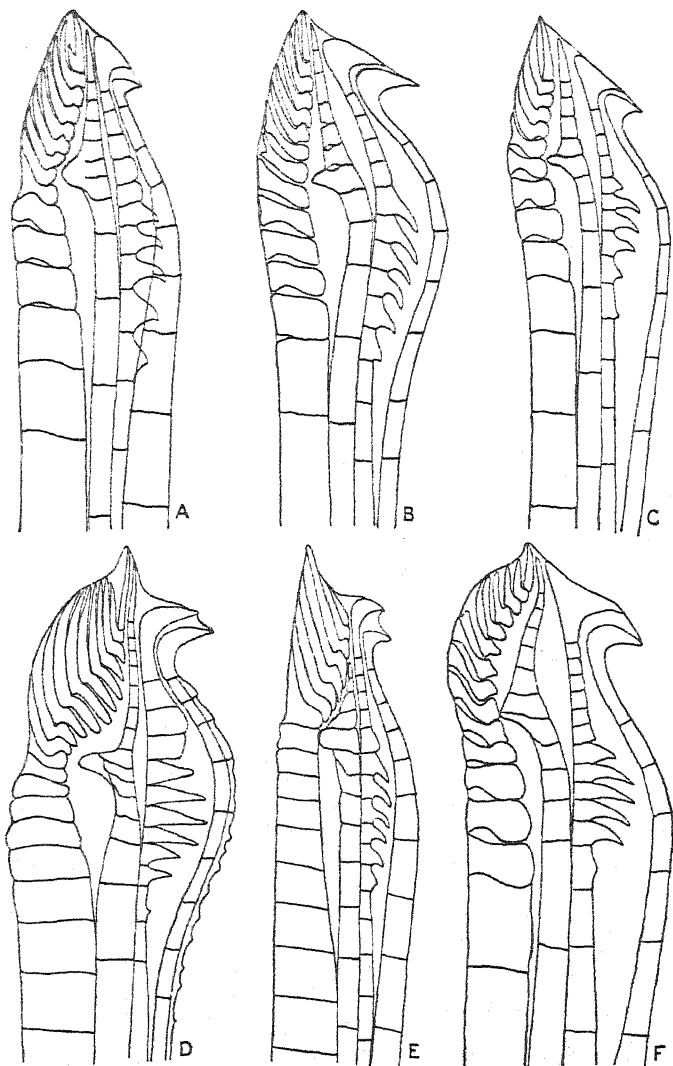
This genus, as now restricted, includes species in which the male intromittent organ is moderately long, nearly  $\frac{1}{2}$  of the length of the fish (without caudal), and is formed on a definite plan which is subject to considerable modification in the different species. The distal segments of the first prolonged ray are produced into processes directed more or less towards its apex; the anterior branch of the second prolonged ray is slender distally and at some distance from the end has an antrorse projection which may be termed the "elbow"; the posterior branch of this ray ends in a retrorse pointed hook or barb, and the segments immediately proximal to the elbow of the anterior branch are produced backwards into serræ; the third prolonged ray ends in a hook more or less similar to that of the second.

Of the 17 species here recognized I have seen males of 9, the distal part of the anal fin of each of them is figured. Of *Gambusia holbrooki* (text-fig. 169 A) I have examined two adult males, of *G. oligosticta* (text-fig. 169 B) four, of *G. nicaraguensis* (text-fig. 168 A) two, of *G. wrayi* (text-fig. 168 B) four, of *G. gracilior* (text-fig. 168 C) three, of *G. dominicensis* (text-fig. 169 C) two, of *G. nigropunctata* (text-fig. 168 F) one, of *G. punctata* (text-fig. 168 D) three, and of *G. senilis* (text-fig. 168 E) one. These suffice to prove that the differences shown in the figures are really specific; the number, form, and size of the modified segments of the first prolonged ray, the number of segments distal to the elbow, the form of the hook, and the number and length of the serræ of the second prolonged ray, and the form of the hook of the third, vary but slightly for each species. The most noticeable variation is in *G. oligosticta*, the other examples differing from the one figured in the addition of a segment to each hook, so that the anterior hook has a short stem and the posterior quite a long one.

The following table gives the number of dorsal rays, of scales in a longitudinal series, and the distribution of the species:—

	D.	Sc.	Distribution.
1. <i>G. holbrooki</i> .....	8	30	Virginia to Alabama.
2. <i>G. patruelis</i> .....	7	31-32	Florida to Texas.
3. <i>G. affinis</i> .....	6-7	30-31	Florida to Tampico.
4. <i>G. senilis</i> .....	8-9	30	Chihuahua, Mexico.
5. <i>G. nicaraguensis</i> .....	7-8	28	S. Mexico to Nicaragua.
6. <i>G. dorii</i> .....	7	32	Nicaragua.
7. <i>G. caudorittata</i> .....	8	31	R. San Juan, Colombia.
8. <i>G. punctata</i> .....	10	31-33	Cuba.
9. <i>G. nigropunctata</i> .....	9	30	"
10. <i>G. melanosticta</i> .....	9-10	29-30	"
11. <i>G. puncticulata</i> .....	9	29-30	"
12. <i>G. melanopleura</i> .....	11-12	30-31	Jamaica.
13. <i>G. wrayi</i> .....	8	31-33	"
14. <i>G. oligosticta</i> .....	8-9	29-31	"
15. <i>G. gracilior</i> .....	8-9	31-33	"
16. <i>G. dominicensis</i> .....	9	28-29	Haiti.
17. <i>G. caymanensis</i> .....	9	30-31	Grand Cayman.

Text-fig. 168.



Distal part of intromittent organ of A. *Gambusia nicaraguensis*. B. *G. urayi*.  
C. *G. gracilior*. D. *G. punctata*. E. *G. senilis*. F. *G. nigropunctata*.

1. *GAMBUSIA HOLBROOKII*. (Text-fig. 169 A, p. 990.)

*Heterandria holbrookii* Girard, Proc. Acad. Philad. 1859, p. 61.  
*Gambusia holbrookii* Günth. Cat. Fish. vi. p. 334 (1866);

Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 82, pl. xi. figs. 4-13.

*Haplochilus melanops* Cope, Proc. Amer. Phil. Soc. xi. 1877, p. 457.

*Zygonoctes atrilatus* Jord. & Brayton, Bull. U.S. Nat. Mus. xii. 1878, p. 84.

♀. Depth of body  $3\frac{1}{2}$  to 4 in the length, length of head 4. Diameter of eye 3 to  $3\frac{1}{2}$  in length of head, interorbital width 2. 30 scales in a longitudinal series. Dorsal 8; origin above posterior end of anal, equidistant from base of pectoral and base of caudal; longest rays  $\frac{2}{3}$  length of head. Anal 10. Pectoral  $\frac{3}{4}$  length of head; pelvics extending to origin of anal. Least depth of caudal peduncle  $\frac{2}{3}$  length of head. Olivaceous; usually a dark bar below the eye; a blackish spot above the vent; dorsal and caudal fins with small dark spots.

♂. Origin of dorsal fin equidistant from eye and base of caudal.

Virginia to Alabama.

Here described from specimens from North Carolina and Virginia, 3 females 38-48 mm. in total length and 2 males of 26 mm.

## 2. GAMBUSIA PATRUELIS.

*Heterandria patruelis* Baird & Girard, Proc. Acad. Philad. 1854, p. 390.

*Gambusia patruelis* Girard, U.S. Mex. Bound. Surv., Fish. p. 72, pl. xxxix. figs. 1-7.

♀. Depth of body 3 in the length, length of head 4. Diameter of eye  $3\frac{1}{4}$  in length of head, interorbital width 2. 31 or 32 scales in a longitudinal series. Dorsal 7; origin behind end of base of anal, nearer to base of caudal than to base of pectoral; longest rays  $\frac{2}{3}$  the length of head. Anal 10; first branched ray longest. Pectoral  $\frac{4}{5}$  length of head; pelvics extending to vent. Least depth of caudal peduncle  $\frac{3}{4}$  length of head. Brownish above, yellowish below; dorsal and caudal fins with small dark spots.

Florida to Texas.

Here described from two specimens from Pensacola (*Jordan*), 47 and 50 mm. in total length.

## 3. GAMBUSIA AFFINIS.

*Heterandria affinis* Baird & Girard, Proc. Acad. Philad. 1854, p. 390.

*Gambusia affinis* Girard, U.S. Mex. Bound. Surv., Fish. p. 72, pl. xxxix. figs. 12-15 (1859); Günth. Cat. Fish. vi. p. 336 (1866).

*Gambusia speciosa* Girard, Proc. Acad. Philad. 1859, p. 121.

*Gambusia gracilis* Girard, l. c.

*Gambusia humilis* Günth, t. c. p. 334.



*Zygonectes brachypterus* Cope, Bull. U.S. Nat. Mus. xx, 1880, p. 34.

*Zygonectes inurus* Jord. & Gilb. Proc. U.S. Nat. Mus. 1882, p. 543.

♀. Depth of body  $3\frac{1}{2}$  to  $4\frac{1}{4}$  in the length, length of head  $3\frac{1}{2}$  to  $4\frac{1}{4}$ . Diameter of eye  $3\frac{1}{2}$  to 4 in length of head, interorbital width  $1\frac{1}{2}$  to 2. 30 or 31 scales in a longitudinal series. Dorsal 6-7; origin above posterior part or end of anal, equidistant from some part of operculum or base of pectoral and base of caudal; longest rays  $\frac{1}{2}$  to  $\frac{2}{3}$  length of head. Anal 10-11. Pectoral from  $\frac{3}{4}$  to nearly as long as head; pelvics reaching vent or origin of anal. Brownish or olivaceous above, yellowish or silvery below; scales dark-edged; usually a dark suborbital bar; dorsal and caudal fins with small dark spots.

Florida to Tampico; Mississippi.

Numerous females, measuring up to 50 mm. in total length, from Florida and Louisiana; one from Tampico.

#### 4. GAMBUSIA SENILIS. (Text-fig. 168 E.)

? *Heterandria nobilis* Baird & Girard, Proc. Acad. Philad. 1853, p. 390.

? *Gambusia nobilis* Girard, U.S. Mex. Bound. Surv., Fish. p. 71, pl. xxxix. figs. 8-11 (1859).

*Gambusia senilis* Girard, Proc. Acad. Philad. 1859, p. 122.

♀. Depth of body 3 to  $3\frac{1}{2}$  in the length, length of head  $3\frac{2}{3}$  to 4. Diameter of eye  $3\frac{1}{2}$  in length of head, interorbital width 2. 30 scales in a longitudinal series. Dorsal 8-9; origin above middle or posterior part of anal, equidistant from base of pectoral and base of caudal; longest rays  $\frac{3}{5}$  length of head. Anal 9-10. Pectoral  $\frac{2}{3}$  length of head; pelvics reaching vent. Least depth of caudal peduncle  $\frac{2}{3}$  length of head. Brownish above, yellowish below; scales dark-edged, especially on sides of abdomen; a dark suborbital bar and a dusky lateral band from eye to base of caudal.

♂. Origin of dorsal fin equidistant from præoperculum and base of caudal.

Chihuahua, Mexico.

Several females, 45 to 50 mm. in total length, and one male of 25 mm.

#### 5. GAMBUSIA NICARAGUENSIS. (Text-fig. 168 A.)

*Gambusia nicaraguensis* Günth. Cat. Fish. vi. p. 336 (1866), and Trans. Zool. Soc. vi. 1868, p. 483, pl. lxxxii. fig. 3; Regan, Biol. Centr.-Amer., Pisces, p. 96 (1907).

*Paragambusia nicaraguensis* Meek, Publ. Columbian Mus., Zool. v. 1904, p. 133.

♀. Depth of body about 3 in the length, length of head  $3\frac{1}{2}$  to 4. Diameter of eye 3 to  $3\frac{1}{2}$  in length of head, interorbital width 2. 28 scales in a longitudinal series. Dorsal 7-8;

origin above or a little behind posterior end of anal, twice as far from middle of eye as from base of caudal; longest rays  $\frac{3}{5}$  or  $\frac{2}{3}$  length of head. Anal 11; second branched ray longest, edge of fin emarginate. Pectoral a little shorter than head; pelvics reaching vent or origin of anal. Least depth of caudal peduncle  $\frac{2}{3}$  length of head. Upper part of body with 2 or 3 series of small dark spots along the rows of scales; dorsal and caudal fins spotted.

♂. Origin of dorsal fin twice as distant from end of snout as from base of caudal.

Southern Mexico; Nicaragua.

Several females, 40 to 55 mm. in total length, and two males of 30 mm., including the types from Lake Nicaragua, and specimens from El Hule (*Meek*) and Coaxacoalcos (*Arnold*).

#### 6. *GAMBUSIA DOVII*, sp. n.

♀. Depth of body  $3\frac{1}{4}$  in the length, length of head  $3\frac{3}{4}$ . Diameter of eye  $3\frac{1}{2}$  in length of head, interorbital width  $1\frac{3}{4}$ . 32 scales in a longitudinal series. Dorsal 7; origin behind end of anal, twice as far from end of snout as from base of caudal. Anal 10; anterior branched rays longest, but edge not emarginate. Least depth of caudal peduncle slightly more than  $\frac{1}{2}$  length of head. Olivaceous; traces of spots on back and on caudal fin.

Lake Nicaragua.

A single specimen of 33 mm., collected by Captain Dow.

#### 7. *GAMBUSIA CAUDOVITTATA*.

Regan, Ann. Mag. Nat. Hist. (8) xii. 1913, p. 471.

Recently described from a single specimen from the Condoto, a tributary of the San Juan, W. Colombia.

#### 8. *GAMBUSIA PUNCTATA*. (Text-fig. 168 D.)

*Gambusia punctata* Poey, Mem. i. p. 384 (1855); Günth. Cat. Fish. vi. p. 334 (1866); Jord. & Everm. Bull. U.S. Nat. Mus. xlvii. 1896, p. 680.

♀. Depth of body 3 to 4 in the length, length of head  $3\frac{1}{2}$  to 4. Diameter of eye 3 to  $3\frac{1}{2}$  in length of head, interorbital width 2. 31 to 33 scales in a longitudinal series. Dorsal 10; origin above posterior end of anal, nearer to base of caudal than to head; longest rays  $\frac{2}{3}$  to  $\frac{1}{2}$  the length of head. Anal 11; last simple or first branched ray longest; edge of fin straight or slightly emarginate. Pectoral  $\frac{3}{4}$  length of head; pelvics reaching vent. Least depth of caudal peduncle  $\frac{1}{2}$  to  $\frac{3}{4}$  length of head. Upper part of side with a dark spot on each scale, forming 3 to 5 regular longitudinal series; usually small dark spots on dorsal and caudal.

♂. Dorsal origin about equidistant from head and base of caudal; longest rays  $\frac{1}{2}$  length of head.

Cuba.

Here described from 16 females, measuring up to 85 mm. in total length, and 3 males of 40 to 50 mm.

9. *GAMBUSIA NIGROPUNCTATA*, sp. n. (Text-fig. 168 F.)

♀. Depth of body  $3\frac{1}{2}$  to  $3\frac{2}{3}$  in the length, length of head  $3\frac{2}{3}$  to  $3\frac{3}{4}$ . Diameter of eye 3 to  $3\frac{1}{4}$  in length of head, interorbital width 2 to  $2\frac{1}{4}$ . 30 scales in a longitudinal series. Dorsal 9; origin above posterior part of anal, equidistant from base of pectoral and base of caudal. Anal 10-11. Least depth of caudal peduncle less than  $\frac{2}{3}$  length of head. Coloration as in related species.

♂. Depth of body 4 in the length, length of head  $3\frac{2}{3}$ . Diameter of eye 3 in length of head, interorbital width  $2\frac{1}{3}$ . Dorsal origin equidistant from middle of opercle and base of caudal; longest rays  $\frac{1}{2}$  length of head. Pectoral  $\frac{2}{3}$  length of head.

Cuba.

Here described from two females of 34 and 50 mm. and a male of 25 mm. from Fernina, Bemba.

10. *GAMBUSIA MELANOSTICTA*, sp. n.

♀. Depth of body 3 in the length, length of head  $3\frac{1}{3}$  to  $3\frac{1}{2}$ . Diameter of eye 3 to  $3\frac{1}{4}$  in the length of head, interorbital width 2. 29 to 30 scales in a longitudinal series. Dorsal 9-10; origin above end of anal, equidistant from base of pectoral and base of caudal; longest rays  $\frac{1}{2}$  to  $\frac{2}{3}$  length of head. Anal 10-11; first branched ray longest. Pectoral  $\frac{2}{3}$  to  $\frac{3}{4}$  length of head; pelvics reaching vent. Least depth of caudal peduncle  $\frac{2}{3}$  length of head. Brownish above, golden below; upper parts with scattered small dark spots; dorsal and caudal fins spotted.

Cuba.

Three females from Havana, 35 to 42 mm. in total length, received from Dr. D. S. Jordan.

11. *GAMBUSIA PUNCTICULATA*.

*Gambusia puncticulata* Poey, Mem. i. pp. 386, 390, pl. xxxi. figs. 6, 7 (1855); Günth. Cat. Fish. vi. p. 334 (1866); Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 87.

♀. Depth of body  $3\frac{1}{4}$  to  $3\frac{1}{2}$  in the length, length of head 4 to  $4\frac{1}{3}$ . Diameter of eye  $3\frac{1}{2}$  in length of head, interorbital width 2. Mouth smaller than in any other species of the genus. 29 or 30 scales in a longitudinal series. Dorsal 9; origin above middle or posterior part of anal, equidistant from head and base of caudal; fin rounded, the longest rays  $\frac{1}{2}$  length of head. Anal 11, pointed. Pectoral  $\frac{2}{3}$  or  $\frac{3}{4}$  length of head; pelvics small. Least depth of caudal peduncle  $\frac{2}{3}$  length of head. Upper parts with scattered small dark spots; 2 or 3 series of small black spots on dorsal and caudal fins.

♂. Origin of dorsal equidistant from eye and base of caudal; longest rays  $\frac{2}{3}$  length of head.

Cuba.

Here described from two females, 35 mm. in total length, presented by Captain Vipan.

## 12. GAMBUSIA MELANOPLEURA.

*Poecilia melanopleura* Gosse, Soj. in Jamaica, p. 84, pl. i. fig. 3 (1851).

*Haplochilus melanopleurus* Günth. Cat. Fish. vi. p. 317 (1866).

*Gambusia melanopleura* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 88.

Depth of body 3 in the length, length of head  $3\frac{1}{2}$ . Diameter of eye 3 to  $3\frac{1}{4}$  in length of head, interorbital width  $1\frac{2}{3}$ . 30 or 31 scales in a longitudinal series. Dorsal 11-12; origin above posterior part of anal, equidistant from base of pectoral and base of caudal; longest rays  $\frac{1}{2}$  length of head. Anal 10-11; branched rays slightly decreasing from first or second. Pectoral  $\frac{3}{4}$  length of head; pelvics reaching vent. Least depth of caudal peduncle  $\frac{2}{3}$  or  $\frac{2}{5}$  length of head. Traces of spots on dorsal and anal fins and in some of a few spots on the back.

Jamaica.

Several females, the largest 47 mm. in total length, types of the species.

## 13. GAMBUSIA WRAYI, sp. n. (Pl. XCIX. figs. 3, 4, and Text-fig. 168 B.)

♀. Depth of body  $3\frac{1}{2}$  to 4 in the length, length of head  $3\frac{2}{3}$  to  $3\frac{4}{5}$ . Diameter of eye 3 to  $3\frac{1}{2}$  in length of head, interorbital width 2. 31 to 33 scales in a longitudinal series. Dorsal 8; origin above posterior part of anal, equidistant from base of pectoral and base of caudal; longest rays  $\frac{1}{2}$  length of head. Anal 10-11; second branched ray longest. Pectoral  $\frac{3}{4}$  length of head; pelvics reaching vent. Caudal rounded or subtruncate. Least depth of caudal peduncle  $\frac{1}{2}$  to  $\frac{2}{5}$  length of head. Coloration probably as in *G. gracilior*.

♂. Dorsal origin equidistant from middle or posterior part of operculum and base of caudal; longest ray  $\frac{2}{3}$  length of head. Least depth of caudal peduncle  $\frac{2}{3}$  or  $\frac{2}{5}$  length of head.

Jamaica.

Eight females measuring up to 55 mm. in total length, and four adult males of 35 to 40 mm., collected by C. A. Wray.

## 14. GAMBUSIA OLIGOSTICTA, sp. n. (Pl. XCIX. figs. 1, 2, and Text-fig. 169 B.)

♀. Depth of body  $2\frac{2}{3}$  to  $3\frac{1}{3}$  in the length, length of head 3 to  $3\frac{1}{2}$ . Diameter of eye 3 to  $3\frac{1}{3}$  in length of head, interorbital width 2. 29 to 31 scales in a longitudinal series. Dorsal 8-9; origin above last 2 or 3 rays of anal, equidistant from base of caudal and base of pectoral; fin rounded, longest rays  $\frac{1}{2}$  length of head. Anal 10-11; first branched ray longest, the rest regularly decreasing. Pectoral  $\frac{3}{4}$  length of head; pelvics reaching vent. Caudal rounded or subtruncate. Least depth of caudal peduncle  $\frac{2}{3}$  or  $\frac{2}{5}$  the length of head. Brownish above, yellowish below; edges of scales darker; usually a dark lateral stripe and a few scattered spots; dorsal and caudal with small spots.

♂. Dorsal origin equidistant from eye or postorbital part of head and base of caudal; longest rays  $\frac{3}{2}$  the length of head.

Jamaica.

Six females, measuring up to 47 mm. in total length, and seven males, the largest 33 mm. Some of these were collected by C. A. Wray, others by the Rev. J. Seed Roberts.

15. *GAMBUSIA GRACILIOR*, sp. n. (Pl. XCIX. figs. 5, 6, and Text-fig. 168 C.)

♀. Depth of body equal to or a little more than length of head, which is  $3\frac{1}{2}$  (young) to 4 in the length of the fish. Diameter of eye 3 in length of head, interorbital width 2. 31 to 33 scales in a longitudinal series. Dorsal 8-9; origin above end of anal, a little nearer to base of caudal than to base of pectoral; fin rounded, longest rays  $\frac{1}{2}$  length of head. Anal 10-11; first or second branched rays longest, the rest regularly decreasing. Pectoral as long as head without snout; pelvics reaching vent. Caudal rounded or subtruncate. Caudal peduncle slender, its least depth  $\frac{1}{2}$  the length of head. Brownish above, yellowish below; usually a narrow dark lateral stripe, sometimes a few scattered dark spots; dorsal and caudal with small spots.

♂. Dorsal further forward and more elevated; origin about equidistant from middle of opercle and base of caudal; longest rays about  $\frac{2}{3}$  the length of head. Least depth of caudal peduncle  $\frac{3}{5}$  the length of head.

Jamaica.

Eight females, measuring up to 50 mm. in total length, and five males, the largest 37 mm., collected by C. Wray. These were mixed up with the examples of *G. oligosticta*, and could be picked out by their more slender form and smaller head, characters found to be associated with differences in the structure of the intromittent organ.

16. *GAMBUSIA DOMINICENSIS*, sp. n. (Pl. XCIX. fig. 7, and Text-fig. 169 C.)

♀. Depth of body  $3\frac{1}{2}$  in the length, length of head  $3\frac{3}{4}$ . Diameter of eye  $3\frac{1}{3}$  in length of head, interorbital width 2. 28 or 29 scales in a longitudinal series. Dorsal 9; origin above posterior end of anal, nearer base of caudal than base of pectoral; longest rays  $\frac{2}{3}$  length of head. Anal 10-11; first branched ray longest. Pectoral  $\frac{3}{4}$  length of head; pelvics reaching origin of anal. Least depth of caudal peduncle  $\frac{3}{5}$  length of head. Brownish, scales dark-edged; a faint lateral stripe; a few scattered dark spots on upper parts; abdomen golden; dorsal and caudal fins with series of small dark spots.

♂. Dorsal origin equidistant from head and base of caudal.

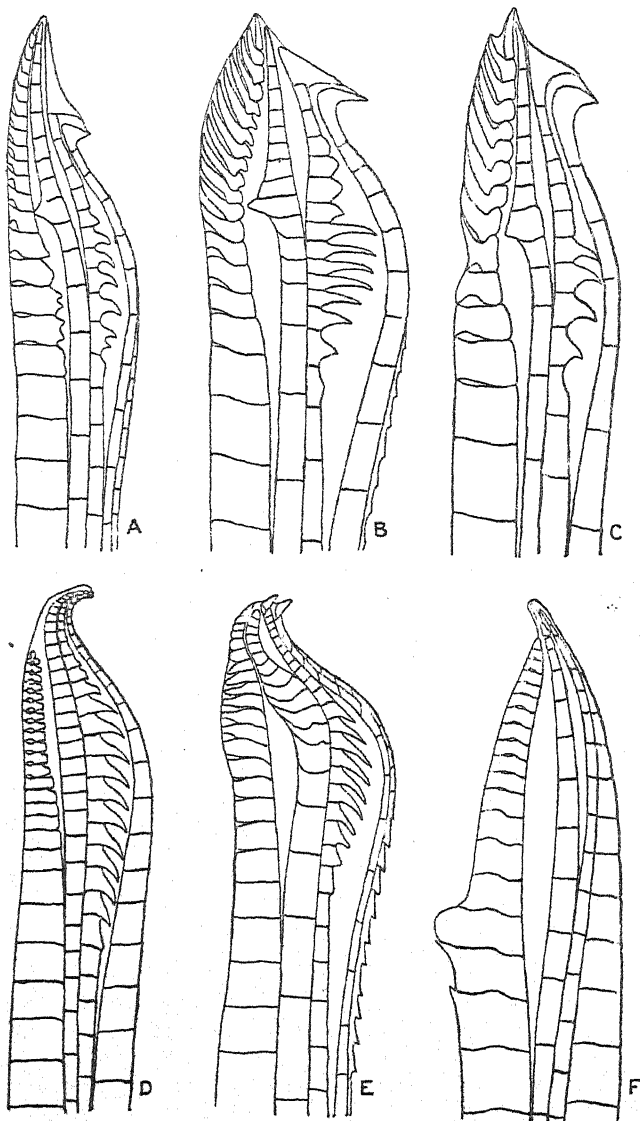
Haiti.

A female of 52 mm., and two males, each 25 mm. in total length, presented by Herr A. Rachow.

## 17. GAMBUSIA CAYMANENSIS, sp. n.

Depth of body  $3\frac{1}{2}$  to 4 in the length, length of head 3 to  $3\frac{1}{3}$ .  
Diameter of eye 3 to  $3\frac{1}{3}$  in length of head, interorbital width

Text-fig. 169.



Distal part of intromittent organ of A. *Gambusia holbrooki*. B. *G. oligosticta*.  
C. *G. dominicensis*. D. *Brachyrhaphis rhabdophora*. E. *Belonesox belizanus*. F. *Alfaro amazonum*.

2 to  $2\frac{1}{4}$ . 30 or 31 scales in a longitudinal series. Dorsal 9; origin above middle of anal, equidistant from operculum and base of caudal; longest rays nearly  $\frac{1}{2}$  length of head. Anal 10; first branched ray longest. Pectoral  $\frac{2}{3}$  length of head; pelvics reaching vent. Least depth of caudal peduncle  $\frac{1}{2}$  length of head. Olivaceous; scales dark-edged; a dark bar below eye; dorsal fin with two series of dark spots; caudal faintly spotted.

Grand Cayman.

Two females, 22 and 26 mm. in total length.

#### 4. *BELONESOX* Kner, 1860.

Sitzungsb. Akad. Wien, xl. p. 419.

Related to *Gambusia*, but the jaws produced, with broad bands of slender, pointed, depressible teeth. Anal fin of male very similar to that of *Gambusia*, differing in that the terminal segments of the first produced ray are not serrated, while rather small retrorse spines at the ends of the third and the posterior branch of the second produced rays represent the hooks of *Gambusia*.

A single species.

*BELONESOX BELIZANUS*. (Text-fig. 169 E.)

*Belonesox belizanus* Kner, Sitzungsb. Akad. Wien, xl. 1860, p. 419, fig.; Günth. Cat. Fish. vi. p. 333 (1866); Meek, Publ. Columbian Mus., Zool. v. 1904, p. 135; Regan, Biol. Centr.-Amer., Pisces, p. 93 (1907).

Depth of body 4 to 6 in the length, length of head nearly 3. Snout  $\frac{1}{2}$  the length of head. 55 to 65 scales in a longitudinal series. Dorsal 9-10. Anal 10-12, in advance of dorsal.

Atlantic Slope of Vera Cruz, British Honduras, and Guatemala.

The largest species of the group, the males attaining 100 mm., the females 200 mm. in total length. Here described from ten specimens from Perez, Belize, and Lake Peten.

#### 5. *PRIAPICHTHYS*, gen. nov.

Differs from *Gambusia* in that the intromittent organ is longer, when laid back nearly reaching the caudal fin, and is quite differently formed; the terminal part is hooked forward and the prolonged rays taper distally and have no specially modified segments, except the usual serræ of the posterior branch of the second; the first prolonged ray does not extend to the apex, and the hook is supported by the anterior branch of the second and the third (text-fig. 170 B).

It is here assumed that five species from Central America and Colombia are congeneric with *P. annectens*, the only species of which I have examined males; in all but *P. parissima* males are known and agree with those of *P. annectens* in their long intromittent organ.

*Synopsis of the Species.*

- I. Origin of dorsal fin in, or a little in advance of, middle of entire length (including caudal fin), above anterior part or middle of anal.
- A. D. 10-12; no black spot on anal fin ..... *annectens*.  
 B. D. 8-9; a blackish spot on anal fin.  
 Length of head  $3\frac{1}{2}$  to  $3\frac{3}{4}$  in length of fish (without caudal) ..... *episcopi*.  
 Length of head  $4\frac{1}{2}$  to  $4\frac{3}{4}$  in length of fish (without caudal) ..... *nigroventralis*.
- II. Origin of dorsal fin much nearer to end of caudal fin than to tip of snout, above posterior part or posterior end of anal. D. 7-8.
- A blackish spot on anal fin ..... *parismina*.  
 7 or 8 dark vertical bars on posterior part of body ..... *tridentiger*.  
 8 or 9 dark bars on anterior  $\frac{2}{3}$  of body ..... *turrubarensis*.

## 1. PRIAPICHTHYS ANNECTENS. (Text-fig. 170 B.)

*Gambusia annectens* Regan, Ann. Mag. N. H. (7) xix. 1907, p. 259, and Biol. Centr.-Amer., Pisces, p. 97, pl. xiv. figs. 5, 6 (1907).

Costa Rica.

## 2. PRIAPICHTHYS EPISCOPI.

*Gambusia episcopi* Steind. Sitzungsber. Akad. Wien, lxxvii. 1878, p. 387, pl. ii. figs. 3, 4.

Panama.

## 3. PRIAPICHTHYS NIGROVENTRALIS.

*Gambusia nigroventralis* Eigenm. Indiana Univ. Studies, 1912, No. 8, p. 26.

Rio San Juan, Colombia.

## 4. PRIAPICHTHYS PARISMINA.

*Gambusia parismina* Meek, Publ. Field. Mus., Zool. x. 1912, p. 71.

Costa Rica.

## 5. PRIAPICHTHYS TRIDENTIGER.

*Gambusia tridentiger* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 89.

Panama.

## 6. PRIAPICHTHYS TURRUBARENSIS.

*Gambusia turrubarensis* Meek, Publ. Field Mus., Zool. x. 1912, p. 71.

Costa Rica.

Perhaps a synonym of *P. tridentiger*.

## 6. PRIAPELLA, gen. nov.

This genus shows relationship to *Priapichthys* in the structure of the long intromittent organ as well as in other characters.



## PRIAPELLA BONITA. (Text-fig. 170 E.)

*Gambusia bonita* Meek, Publ. Columbian Mus., Zool. v. 1904, p. 132, fig. 39; Regan, Biol. Centr.-Amer., Pisces, p. 95 (1907).

Rio Papaloapam in Mexico.

## 7. PSEUDOXIPHOPHORUS Bleek., 1863.

Atl. Ichth. iii. p. 140; Günth. Cat. Fish. vi. p. 332 (1866).

Differs from *Priapichthys* in the longer dorsal fin originating in advance of the anal (♀) and in the structure of the intermittent organ (text-fig. 170 C), with the anterior branch of the second prolonged ray ending in an unsegmented antrorse hook, at the base of which the first and third prolonged rays terminate.

There are three species from Mexico and Central America, but males of one only (*P. bimaculatus*) have been described.

## 1. PSEUDOXIPHOPHORUS TERRABENSIS.

*Gambusia terrabensis* Regan, Ann. Mag. N. H. (7) xix. 1907, p. 260; Biol. Centr.-Amer., Pisces, p. 97, pl. xii. fig. 7 (1907).

Dorsal 12-14; origin nearly equidistant from tip of snout and base of caudal. Anal 9-10; origin nearly below middle of dorsal. No dark spot above pectoral.

Rio Grande de Terraba, Costa Rica.

## 2. PSEUDOXIPHOPHORUS JONESII.

*Mollienisia jonesii* Günth. Ann. Mag. N. H. (4) xiv. 1874, p. 371.

*Pseudoxiphophorus pauciradiatus* Regan, Ann. Mag. N. H. (7) xiii. 1904, p. 256 and xvi. 1905, p. 362.

*Gambusia jonesii* Regan, Biol. Centr.-Amer., Pisces, p. 97, pl. xii. fig. 8 (1907).

Dorsal 11-13; origin equidistant from tip of snout and middle or posterior part of caudal. Anal 9-11, below anterior part of dorsal. A dark spot above pectoral.

Mountain lakes and streams of Central Vera Cruz, Mexico.

## 3. PSEUDOXIPHOPHORUS BIMACULATUS. (Text-fig. 170 C.)

*Xiphophorus bimaculatus* Heck. Sitzungsab. Akad. Wien, i. 1848, p. 296, pl. ix. figs. 1, 2.

*Pseudoxiphophorus bimaculatus* Günth. Cat. Fish. vi. p. 332 (1866); Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 81.

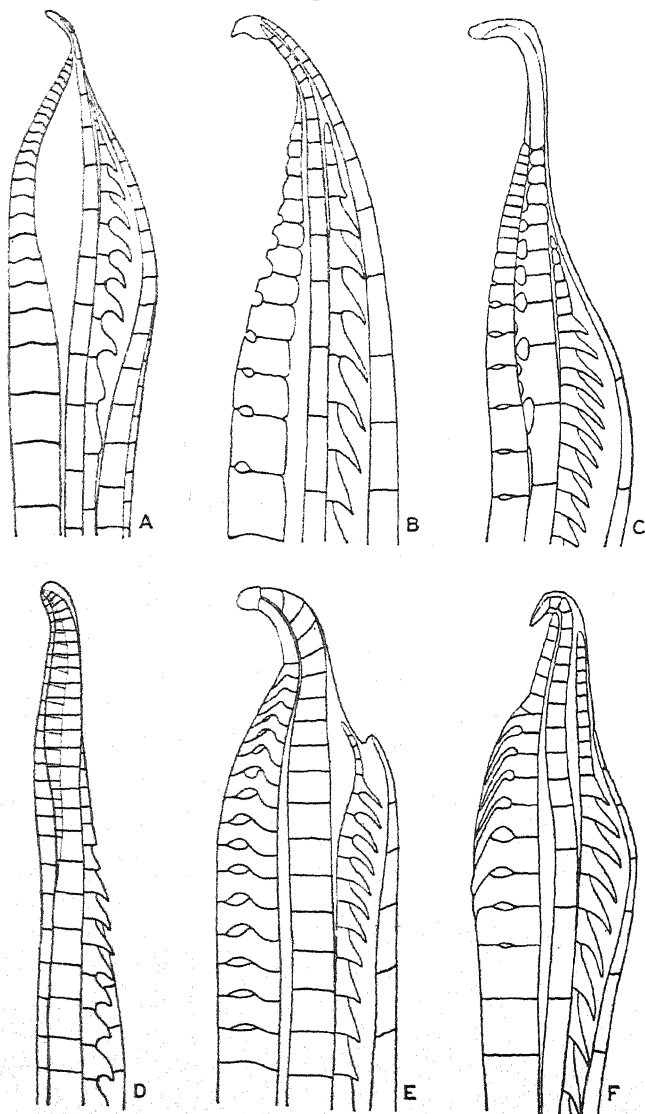
*Gambusia bimaculata* Regan, Biol. Centr.-Amer., Pisces, p. 98, pl. xiv. fig. 4.

Dorsal 13-17; origin nearly equidistant from tip of snout and

base of caudal. Anal 9-11, below anterior part of dorsal. A dark spot above pectoral.

Southern Mexico, British Honduras, and Guatemala.

Text-fig. 170.



Distal part of intromittent organ of A. *Heterandria formosa*. B. *Priapichthys annectens*. C. *Pseudorhaphorus bimaculatus*. D. *Paciliopsis presidionis*. E. *Priapella bonita*. F. *Pseudopacilia festa*.

## 8. HETERANDRIA, Agass., 1853.

Amer. Journ. Sci. xvi. p. 135.

*Girardinus* (part.) Günth. Cat. Fish. vi. p. 351 (1866).

*Heterandria* (part.) Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 90.

Differs from *Gambusia* and *Priapichthys* in the small transverse mouth and compressed pointed teeth, the enlarged outer teeth forming a close-set series. The intromittent organ is elongate, as in *Priapichthys*, and its structure indicates a close relationship to that genus. It differs in that the third prolonged ray is scarcely longer than the posterior branch of the second, so that the hook is supported only by the anterior branch of the second.

Two species from the United States and Mexico.

## 1. HETERANDRIA FORMOSA. (Text-fig. 170 A.)

*Heterandria formosa* Agass. Amer. Journ. Sci. xix. 1855, p. 136; Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 91, pls. iv. fig. 7, viii. fig. 8, and xi. figs. 1-3; Jord. & Everm. Bull. U.S. Nat. Mus. xlvii. 1896, p. 687.

*Girardinus formosus* Günth. Cat. Fish. vi. p. 354 (1866).

Depth of body  $3\frac{1}{2}$  to 4 in the length, length of head  $3\frac{1}{2}$  to 4. Diameter of eye 3 to  $3\frac{2}{3}$  in length of head, interorbital width 2. 28 to 30 scales in a longitudinal series. Dorsal 7-8; origin above middle of anal, scarcely nearer to end of caudal than to tip of snout. Anal 10. A dark lateral band crossed by several vertical bars; a blackish spot on basal part of dorsal, another on anal.

South Carolina to Florida.

Eight specimens, the largest female 30 mm., the males 15 to 20 mm. in total length.

## 2. HETERANDRIA FASCIATA.

*Gambusia fasciata* Meek, Publ. Columbian Mus., Zool. v. 1904, p. 129, fig. 37; Regan, Biol. Centr.-Amer., Pisces, p. 95 (1907).

Very similar to the preceding in form and coloration, except for the absence of the lateral band, differing especially in the more posterior dorsal fin, its origin above end of anal and much nearer to end of caudal than to tip of snout. Dorsal 8. Anal 9-10. 32 scales in a longitudinal series.

Southern Mexico.

Total length 55 mm.

Six specimens from Oaxaca and Tequesixtlan (*Gadow*).

The male of this species has not yet been described.

## 9. PSEUDOPÆCILIA, gen. nov.

Closely related to *Heterandria*, but with the teeth broad truncated incisors and the intromittent organ somewhat different in structure.

*PSEUDOPÆCILIA FESTE.* (Text-fig. 170 F.)

*Pæcilia festæ* Bouleng. Boll. Mus. Zool. Torino, xiii. 1898, No. 329, p. 13.

Santa Elena, Western Ecuador.

#### 10. *PÆCILIOPSIS*, gen. nov.

This genus has the mouth and dentition of *Pæcilia*, but in the males the pelvic fins are neither enlarged nor modified, and the intromittent organ is long and slender. The first prolonged ray and the anterior branch of the second extend to the end of the fin and are somewhat curved forward distally; the posterior branch of the second is short and the third still shorter and slender distally, so that the serrations of the second project beyond it (text-figs. 170 D and 171 B).

Mexico, Central America, and Colombia.

#### *Synopsis of the Species.*

- |  |                          |
|--|--------------------------|
| 1. Dorsal origin behind that of anal.  |                          |
| Sides of body with a series of vertical bars .....   | 1. <i>presidionis</i> .  |
| A lateral series of spots, usually more than 8 in number and smaller than the eye .....                                      | 2. <i>lutzi</i> .        |
| A lateral series of 4 to 8 spots, each about as large as the eye .....   | 3. <i>pleurospilus</i> . |
| No bars or spots .....   | 4. <i>retropinna</i> .   |
| 2. Dorsal origin in advance of that of anal.   |                          |
| Diameter of eye 3 to $3\frac{1}{4}$ in length of head, which is $3\frac{1}{2}$ to $3\frac{3}{4}$ in the length of fish ..... | 5. <i>isthmensis</i> .   |
| Diameter of eye $2\frac{1}{2}$ to $2\frac{3}{4}$ in length of head, which is 4 to $4\frac{1}{2}$ in the length of fish ..... | 6. <i>pittieri</i> .     |

#### 1. *PÆCILIOPSIS PRESIDIONIS*. (Text-fig. 170 D.)

*Pæcilia presidionis* Jord. & Culver, Proc. Calif. Acad. (2) v. 1895, p. 413, pl. xxix.

*Girardinus presidionis* Regan, Biol. Centr.-Amer., Pisces, p. 99 (1907).

As I have stated in the 'Biologia' this form and the next seem to differ from *P. pleurospilus* only in coloration, and should perhaps be regarded as subspecies of that species.

Rio Presidio in Sinaloa.

*Heterandria colombianus* Eigenm. (Indiana Univ. Studies, 1912, No. 8, p. 27), from brackish water at the mouth of the R. Dagua, Colombia, seems to be extremely similar to *P. presidionis*.

#### 2. *PÆCILIOPSIS LUTZI*.

*Heterandria lutzi* Meek, Publ. Colombian Mus., Zool. v. 1904, p. 148, fig. 47.

*Girardinus lutzi* Regan, Biol. Centr.-Amer., Pisces, p. 99 (1907).

Oaxaca, Mexico; R. Motagua in Guatemala.

3. *PÆCILIOPSIS PLEUROSPILUS*.

*Girardinus pleurospilus* Günth. Cat. Fish. vi. p. 355 (1866). and Trans. Zool. Soc. vi. 1868, p. 486, pl. lxxxvii. fig. 1; Regan, Biol. Centr.-Amer., Pisces, p. 100 (1907).

Lakes Dueñas and Nacasil in Guatemala.

4. *PÆCILIOPSIS RETROPINNA*.

*Pæcilia retropinna* Regan, Ann. Mag. Nat. Hist. (8) ii. 1908, p. 458.

Costa Rica.

5. *PÆCILIOPSIS ISTHMENSIS*, sp. n. (Pl. C. figs. 3, 4; and Text-fig. 171 B.)

♀. Depth of body  $2\frac{1}{2}$  to 3 in the length, length of head  $3\frac{1}{2}$  to  $3\frac{3}{4}$ . Diameter of eye 3 to  $3\frac{1}{4}$  in length of head, interorbital width  $1\frac{1}{2}$  to 2. 26 to 28 scales in a longitudinal series. Dorsal 9-10; origin equidistant from anterior edge of eye and base of caudal; longest ray  $\frac{2}{3}$  length of head. Anal 10; origin below fourth or fifth ray of dorsal; first branched ray longest,  $\frac{3}{4}$  length of head or more. Pectoral a little shorter than head; pelvics reaching anal. Least depth of caudal peduncle  $\frac{2}{3}$  or  $\frac{3}{4}$  length of head. Olivaceous; scales dark-edged; a blackish spot above the vent; fins dusky, the dorsal with blackish basal band and dark edge.

♂. Dorsal origin equidistant from tip of snout and base of caudal, or nearer former; intromittent organ, when laid back, nearly or quite reaching caudal fin; indistinct cross-bars on body.

Colon, Panama.

8 females, 35 to 60 mm. in total length, and 4 males of 35 to 42 mm., presented by Herr A. Rachow.

6. *PÆCILIOPSIS PITTIERI*.

*Pæcilia pittieri* Meek, Field Mus. Publ., Zool. x. 1912, p. 71.

Closely related to the preceding, but described as with a smaller head and larger eye.

La Junta, Costa Rica.

Total length 43 to 65 mm., males to 53 mm.

11. *BRACHYRHAPHIS*, gen. nov.

Differs from *Gambusia* in the shorter intromittent organ ending in a small retrorse hook formed by the second and third produced rays.

*BRACHYRHAPHIS RHABDOPHORA*. (Text-fig. 169 D.)

*Gambusia rhabdophora* Regan, Ann. Mag. Nat. Hist. (8) ii. 1908, p. 457.

Costa Rica.

Specimens recently received show that in this species the origin of the anal fin may be behind below or in advance of that of the dorsal.

*Gambusia umbratilis* Meek (Publ. Field Mus., Zool. x. 1912, p. 70) seems to differ from *B. rhabdophora* only in the larger eye.

## 12. LEPTORHAPHIS, gen. nov.

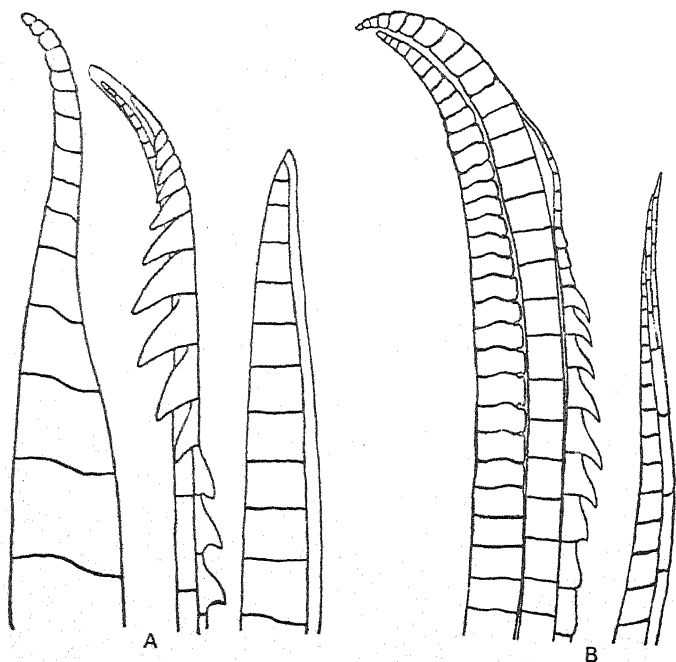
Differs from *Gambusia* only in the structure of the intromittent organ, which is longer and more slender than in that genus and slightly curved backwards distally. The first produced ray is not serrated, gradually tapers distally, and extends nearly to the tip of the fin; the second is slightly longer and has the posterior branch almost as long as the anterior and with the usual serrations, which project externally; the third ray also seems to reach nearly to the tip of the fin and appears to meet the first and form a complete tube.

### LEPTORHAPHIS INFANS.

? *Xiphophorus gracilis* Heck. Sitzungsab. Akad. Wien, i. 1848, p. 300, pl. ix. figs. 3, 4.

*Gambusia infans* Woolman, Bull. U.S. Fish. Comm. 1894,

Text-fig. 171.



Distal part of intromittent organ of A. *Phalloptychus januarius* and B. *Paeciliopsis isthmensis*. The rays have been separated.

p. 62, pl. ii. fig. 3; Meek, Publ. Columbian Mus., Zool. v. 1904, p. 131, fig. 38; Regan, Biol. Centr.-Amer., Pisces, p. 96 (1907).  
*Gambusia gracilis* Meek, t. c. p. 130.

Rio Lerma and Rio Balsas in Mexico; ? Orizaba.

### 13. PHALLOPTYCHUS Eigenmann.

Proc. U.S. Nat. Mus. xxxii. 1907, p. 430.

Mouth and dentition of *Pacilia*. Intromittent organ long and slender; third produced ray crossing second on right side near base, meeting first and forming a closed tube; second twisted distally so that the serrations are directed laterally or even forwards.

PHALLOPTYCHUS JANUARIUS. (Pl. C. figs. 7, 8, and text-fig. 171 A.)

*Girardinus januaris* Hensel, Arch. f. Nat. xxxiv. 1868, p. 360, and xxxv. 1869, p. 89.

*Girardinus iheringii* Bouleng. Ann. & Mag. Nat. Hist. (6) iv. 1889, p. 266.

*Girardinus zonatus* Schreiner, Arch. Mus. Rio Janeiro, xii. 1903, p. 7.

S.E. Brazil; La Plata.

This species may at once be recognized by its coloration, having several narrow blackish vertical stripes on each side of the body. Dorsal 9; origin above or a little behind that of anal.

### 14. PHALLOCEROS Eigenm.

Proc. U.S. Nat. Mus. xxxii. 1907, p. 431.

Mouth small, but bones of lower jaw rather firmly joined; teeth oar-shaped, slender, curved, as in *Pacilia*. Intromittent organ long (about  $\frac{2}{3}$  length of fish to base of caudal); last segment of first produced ray modified into an antrorse appendage which bifurcates, each fork antler-like in form; anterior branch of second ending just beyond the first in an antrorse process.

PHALLOCEROS CAUDOMACULATUS. (Pl. C. figs. 5, 6, and text-fig. 172 C.)

*Girardinus caudimaculatus* Hensel, Arch. f. Nat. xxxiv. 1868, p. 362, and xxxv. 1869, p. 89.

*Glaridodon januaris* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 42.

S.E. Brazil; La Plata.

The coloration readily distinguishes this species from *Phalloptychus januaris*. Plain olivaceous, usually with a vertical blackish spot on side below dorsal fin; sometimes a lateral series of dusky bars. Dorsal 7-8; origin above middle or posterior part of anal.

15. *CNESTERODON* Garman.

Mem. Mus. Comp. Zool. xix. 1895, p. 43.

*Gulapinnus* Langer, Morph. Jahrb. xlvii. 1913, p. 207.

Mouth small, but rami of lower jaw rather firmly joined and teeth chisel-shaped, broader than in *Pacilia*. Intromittent organ long (nearly  $\frac{2}{3}$  length of fish to base of caudal); last segment of first produced ray an appendage which is not forked, but is very long, peculiarly curved, and pointed distally; second ending in a process which is not or scarcely antrorse; third terminating in a hook, as in *Gambusia*.

*CNESTERODON* DECEMMACULATUS. (Text-fig. 172 B.)

*Pacilia decemmaculata* Jenyns, Zool. 'Beagle,' Fish. p. 115, pl. xxii. fig. 1 (1842).

*Pacilia gracilis* Cuv. & Val. Hist. Nat. Poiss. xviii. 1846, p. 133.

*Cnesterodon decemmaculatus* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 44.

*Cnesterodon carnegiei* Haseman, Ann. Carnegie Mus. vii. 1911, p. 385, pl. lxxxiii.

La Plata; Rio Grande do Sul.

A small species, easily recognized by the lateral series of dark, rounded or vertically expanded spots. Dorsal 8-9; origin above or a little behind that of anal.

16. *GLARIDICHTHYS* Garman, 1896.

*Glaridodon* (non Seeley, Proc. R. Soc. xlv. 1888, p. 135); Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 40.

*Glaridichthys* Garman, Amer. Nat. xxx. 1896, p. 232.

This genus is well distinguished by the dentition and by the structure of the intromittent organ. It includes a single species from Cuba and perhaps one from Chihuahua, but males of the latter have not been described.

1. *GLARIDICHTHYS* UNINOTATUS.

*Girardinus uninotatus* Poey, Mem. ii. pp. 309, 383 (1861); Günth. Cat. Fish. vi. p. 351 (1866).

*Glaridodon uninotatus* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 41.

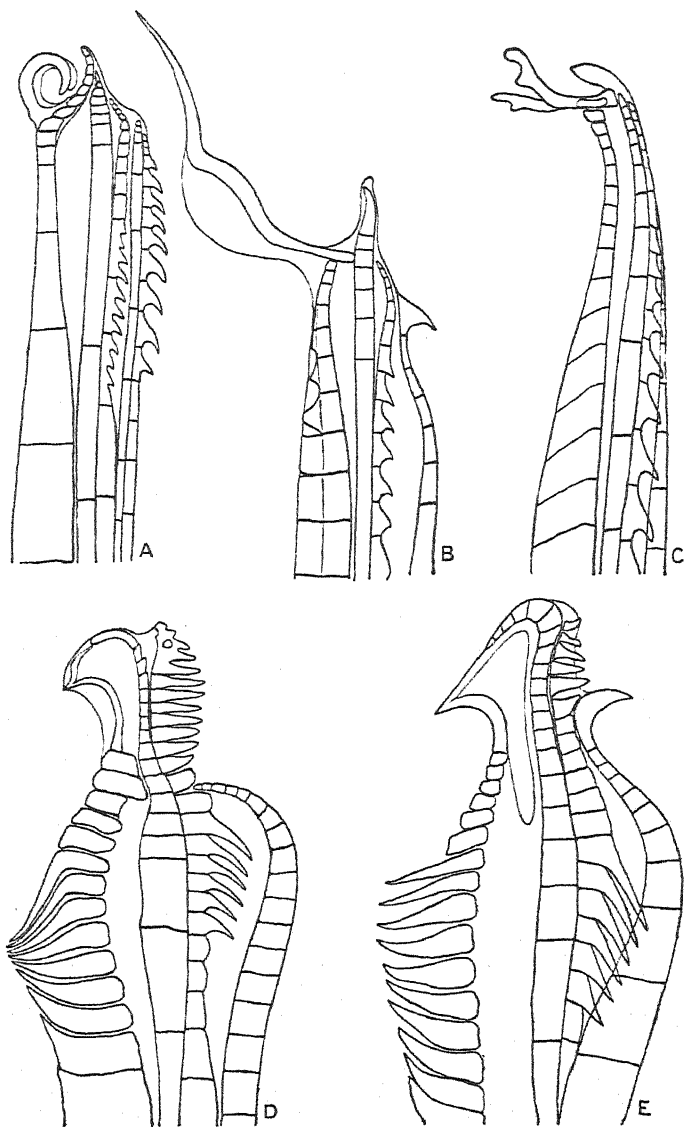
*Glaridichthys falcatus* Eigenm. Bull. U.S. Fish. Comm. xxii. p. 224, fig. (1904).

*Glaridichthys torralbasi* Eigenm. t. c. p. 225, fig.

♀. Depth of body  $3\frac{1}{2}$  to  $4\frac{1}{2}$  in length, length of head 4 to 5. Eye large, more than  $\frac{1}{3}$  of length of head. 28 to 31 scales in a longitudinal series. Dorsal 9-11; origin nearly equidistant from head and base of caudal. Anal 10; origin well in advance of that of dorsal. Olivaceous; edges of scales usually darker; often



Text-fig. 172.



Distal part of intromittent organ of A. *Girardinus metallicus*. B. *Cnesterodon decemmaculatus*. C. *Phalloceros caudomaculatus*. D. *Platypœcilus maculatus*. E. *Xiphophorus helleri*.

a lateral series of short vertical bars; usually a blackish spot above origin of anal fin.

♂. Dorsal origin nearly equidistant from eye and base of caudal. Bars on side well marked; lateral spot indistinct; a blackish streak behind first produced ray of anal.

Here described from several specimens up to 75 mm. in total length from Cuba, including a male of 47 mm. extremely similar to the type of *G. torralbasi*, and co-types of *G. falcatus*. The last is a pale variety without the lateral spot, but structurally similar to *G. uninotatus*; the slight production of the vertical fins is found in several specimens with the typical coloration.

## 2. GLARIDICHTHYS LATIDENS.

*Glaridodon latidens* Garm. Mem. Mus. Comp. Zool. xix. 1895, p. 42.

Chihuahua; Mexico.

## 17. TOXUS Eigenm., 1904.

Bull. U.S. Fish. Comm. xxii. p. 226.

This genus differs from the preceding only in the dentition.

### TOXUS RIDDLEI.

Eigenm. l. c. figs.

Cuba.

## 18. GIRARDINUS Poey, 1855.

Mem. i. pp. 383, 390; Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 45.

Mouth and dentition as in *Poecilia*, but intromittent organ formed exactly as in the two preceding genera.

A single species from Cuba.

### GIRARDINUS METALLICUS. (Text-fig. 172 A.)

Poey, Mem. i. pp. 387, 391, pl. xxxi, figs. 8-11 (1855); Günth. Cat. Fish. vi. p. 351 (1866); Garm. Mem. Mus. Comp. Zool. xix. 1895, p. 46.

*Girardinus denticulatus* Garm. t. c. p. 47.

*Girardinus creolus* Garm. l. c.

*Girardinus garmani* Eigenm. Bull. U.S. Fish. Comm. xxii. p. 226, fig. (1904).

*Heterandria cubensis* Eigenm. t. c. p. 227, fig.

Depth of body 3 to 4 in length, length of head 4 to  $4\frac{1}{2}$ . Diameter of eye  $2\frac{2}{3}$  to 3 in length of head. 27 to 31 scales in a longitudinal series. Dorsal 9-10; origin nearly equidistant from base of pectoral and base of caudal (a little nearer head than caudal in ♂). Anal 10-12; origin well in advance of dorsal. Olivaceous; edges of scales darker; usually a lateral

series of dark bars; dorsal with anterior edge dark and usually a blackish spot or band posteriorly near base.

Cuba.

Several specimens up to 70 mm. in total length.

#### 19. PAMPHORICHTHYS, gen. nov.

Mouth small; bones of lower jaw firmly united; a series of firmly set, slender, pointed teeth and a band of much smaller teeth within. Intestine long, coiled. Males with anal and pelvic fins below pectorals, the former a slender pointed organ about  $\frac{1}{3}$  the length of the fish (without caudal), the latter also modified, the outer rays produced, the inner about  $\frac{1}{2}$  as long and forming a projection near their ends.

This genus is based on Garman's *Heterandria minor*, which seems to differ from *Heterandria* in the more slender teeth, longer intestine, and shorter intromittent organ, but especially in the modification of the pelvic fins in the male.

##### PAMPHORICHTHYS MINOR.

*Heterandria minor* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 92.

Amazon.

#### 20. PAMPHORIA, gen. nov.

Mouth small; bones of lower jaw rather firmly joined; a series of broad incisors and a band of minute tricuspid teeth within. Intestine long. Males with anal fin much advanced, forming an intromittent organ that is longer than the head, and with the second ray of the pelvics produced.

##### PAMPHORIA SCALPRIDENS.

*Cnesterodon scalpridens* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 45, pl. v. fig. 12. pl. viii. fig. 17.

Amazon.

#### 21. PLATYPÆCILUS Günth., 1866.

Cat. Fish. vi. p. 350.

Mouth small, transverse; bones of lower jaw loosely connected; an outer series of slender curved teeth, somewhat expanded and compressed towards their apices, spoon-shaped or oar-shaped. Males with the pelvic fins enlarged, nearly as long as the intromittent organ, which is unprotected by a hood, but has the distal end remarkably modified (text-fig. 172 D).

Two species from Mexico, with the intromittent organ precisely similar in structure.

##### 1. PLATYPÆCILUS COUCHIANUS.

*Limia couchiana* Girard, Proc. Acad. Philad. 1859, p. 116.

*Pœcilia couchiana* Regan, Biol. Centr.-Amer., Pisces, p. 104, pl. xiv. fig. 1 (1907).

Depth of body about  $2\frac{3}{4}$  in the length, length of head about 4. 23 to 27 scales in a longitudinal series. Dorsal 9-11; origin equidistant from snout and anterior part of caudal. Anal 7-8, opposite posterior  $\frac{1}{2}$  of dorsal. Blackish or brownish above, yellowish below, the two colours sharply separated.

Rio San Juan at Monterey.

2. *PLATYPÆCILUS MACULATUS*. (Text-fig. 172 D.)

*Platyæcilus maculatus* Günth. Cat. Fish. vi. p. 350 (1866).

*Pœcilia maculata* Regan, Biol. Centr.-Amer., Pisces, p. 105 (1907).

Closely related to *P. couchianus*. Depth of body 2 to  $2\frac{2}{3}$  in the length, length of head  $3\frac{1}{3}$  to  $3\frac{2}{3}$ . Anal 8-9. Olivaceous; a dark spot or crescent or a pair of spots at base of caudal.

Atlantic Coast streams of Mexico and Guatemala.

22. *XIPHOPHORUS* Heckel, 1848.

Sitzungsb. Akad. Wien, i. p. 291.

Closely related to the preceding, as is shown by the great similarity in the structure of the anal fins of the males (text-fig. 172 E). The species occur in rivers of the Atlantic Slope from Tamaulipas to Guatemala. After examination of a large series of specimens I conclude that only 3 species are well established.

1. *XIPHOPHORUS MONTEZUMÆ*.

Jord. & Snyder, Bull. U.S. Fish. Comm. 1900, p. 131, fig. 11; Regan, Biol. Centr.-Amer., Pisces, p. 107 (1907).

Dorsal 11-13. Anal 6-8. Scales 27 to 29. Depth about 3 in the length, length of head about 4. Yellowish; scales of upper part of body dark-edged; usually a dark lateral stripe.

Rio Panuco, Mexico.

2. *XIPHOPHORUS HELLERI*. (Text-fig. 172 E.)

Heck. Sitzungsb. Akad. Wien, i. 1848, p. 291, pl. viii.; Günth. Cat. Fish. vi. p. 349 (1866); Regan, Biol. Centr.-Amer., Pisces, p. 107 (1907).

*Xiphophorus guentheri* Jord. & Everm. Bull. U.S. Nat. Mus. xvii. 1896, p. 702.

*Xiphophorus jalapæ* Meek, Publ. Columbian Mus., Zool. v. 1903, p. 136, pl. xi.

*Xiphophorus strigatus* Regan, t. c. pl. xiv. fig. 7.

Dorsal 11-14. Anal 8-10. Scales 26 to 30. Depth 3 to 4 in the length, length of head 4 to  $4\frac{2}{5}$ . Sides of body blue, with red stripes between the series of scales.

Southern Mexico; Guatemala.

Mexican examples have nearly always a strong stripe from eye to base of caudal (*strigatus*), the males sometimes with another backwards from axil of pectoral (*helleri*, *jalapæ*); in specimens

from Guatemala there is, as a rule, no strong lateral stripe (*guentheri*).

*Xiphophorus rachovii* Regan (Ann. Mag. Nat. Hist. (8) viii. 1911, p. 373), from Puerto Barrios, Guatemala, has a pair of black spots at the base of the caudal fin; other examples received later from Puerto Barrios lack these spots, but are not very different in other respects. Whether this is another variety of *X. helleri* or a hybrid with *Platypecilus maculatus*, as some aquarium-writers in Germany believe, still remains to be settled.

### 3. XIPHOPHORUS BREVIS.

Regan, Ann. Mag. Nat. Hist. (7) xix. 1907, p. 65, and Biol. Centr.-Amer., Pisces, p. 108, pl. xiv. figs. 8, 9.

Dorsal 13-15. Anal 9-10. Scales 27. Depth  $2\frac{1}{2}$  to  $2\frac{2}{3}$  in length, length of head  $3\frac{3}{5}$  to  $3\frac{2}{4}$ . No strong lateral stripe.

British Honduras.

### 23. PÆCILIA Schneider, 1801.

Bloch's Syst. Ichth. p. 452.

*Pæcilia* (part.) Günth. Cat. Fish. vi. p. 339 (1866); Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 52.

Mouth small, transverse; teeth slender, curved, expanded towards the tip, spoon- or oar-shaped, forming a series with a band of minute teeth within; bones of lower jaw loosely connected. Pelvic fins in male enlarged, the second ray prolonged. Intromittent organ short, its tip protected anteriorly by a cutaneous hood; first prolonged ray without terminal spine, with several segments not far from the end forming acute serrations; last ray simple, without appendages (text-fig. 173 A-C).

As now restricted this genus only includes four (or five) species from South America.

#### *Synopsis of the Species.*

- |   |                      |
|---|----------------------|
| I. Dorsal 7-9; origin nearly above that of anal .....   | 1. <i>vivipara</i> . |
| II. Dorsal 6-7.   |                      |
| Origin of dorsal above posterior end of anal: usually a dark spot above pectoral, equidistant from head and dorsal fin .....                            | 2. <i>para</i> .     |
| Origin of dorsal above middle or posterior part of anal; a dark spot on each scale and dark stripes between the series of scales on sides of body ..... | 3. <i>picta</i> .    |
| Origin of dorsal above middle of anal; a blackish spot or bar at base of caudal fin .....   | 4. <i>branneri</i> . |

#### 1. PÆCILIA VIVIPARA. (Text-fig. 173 C.)

*Pæcilia vivipara* Schneid. Bloch's Syst. Ichth. p. 452, pl. lxxxvi. fig. 2 (1801); Günth. Cat. Fish. vi. p. 344 (1866); Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 53.

*Pæcilia schneideri* Val. in Humboldt, Obs. Zool. ii. p. 159 (1828); Cuv. & Val. Hist. Nat. Poiss. xviii. p. 135 (1846).

Proc. Zool. Soc.—1913, No. LXVII.

*Pæcilia surinamensis* Val. t. c. p. 158, pl. li. fig. 1; Cuv. & Val. t. c. p. 120.

*Pæcilia unimaculata* Val. t. c. p. 158, pl. li. figs. 2, 5, 6; Cuv. & Val. t. c. p. 128; Günth. t. c. p. 346.

♀. Depth of body  $2\frac{3}{4}$  to 4 in the length, length of head  $3\frac{1}{3}$  to  $4\frac{1}{3}$ . Diameter of eye 3 to 4 in length of head, interorbital width  $1\frac{3}{4}$  to 2. 25 to 27 scales in a longitudinal series. Dorsal 7-9; origin nearly above that of anal and equidistant from some part of operculum and base of caudal. Anal 8-10. Pectoral a little shorter than head; pelvics reaching vent. Least depth of caudal peduncle  $\frac{2}{3}$  to  $\frac{4}{5}$  length of head. Olivaceous; edges of scales usually darker; body often with dark cross-bars; often a blackish spot, which may be pale-edged, on upper part of side 2 or 3 scales in front of dorsal fin; often a pair of blackish spots at base of caudal above and below, extending along margins of fin; fins sometimes immaculate, but dorsal and caudal sometimes with series of small spots, or dorsal with one or two blackish bands.

♂. Dorsal a little further forward and higher than in ♀.

Venezuela and Leeward Islands to the La Plata.

Numerous examples, the largest female 80 mm. and the largest male 60 mm.

## 2. *PÆCILIA PARÆ*. (Text-fig. 173 B.)

*Pæcilia vivipara paræ* Eigenm. Ann. N.Y. Acad. vii. 1894, p. 629.

? *Pæcilia amazonica* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 64.

*Acanthophaelus bifurcus* Eigenm. Mem. Carnegie Mus. v. 1912, p. 459, pl. lxx. figs. 4-6.

♀. Depth of body  $3\frac{1}{2}$  in the length, length of head  $3\frac{1}{2}$ . Diameter of eye  $3\frac{1}{4}$  in length of head, interorbital width 2. 28 scales in a longitudinal series. Dorsal 6; origin above posterior end of anal, nearly equidistant from head and base of caudal; middle rays longest,  $\frac{1}{2}$  length of head. Anal 8-9. Pectoral  $\frac{3}{4}$  length of head; pelvics extending to origin of anal. Least depth of caudal peduncle  $\frac{3}{5}$  length of head. Olivaceous; usually a pale lateral stripe; a vertically expanded dark spot with pale margin on upper part of side, nearly equidistant from head and dorsal fin; fins immaculate.

♂. Dorsal origin nearer to head than to base of caudal; longest rays  $\frac{3}{4}$  length of head. A dark spot above pectoral (as in ♀), a larger one just above anal fin, a third on caudal peduncle; dorsal and caudal sometimes spotted, latter with dark upper edge.

Amazon; Guiana.

Four specimens, two females of 28 mm. and two males of 22 and 24 mm. in total length, received from Prof. Eigenmann; these are co-types of the species from Para and of *A. bifurcus* from British Guiana. The intromittent organ is figured (text-fig. 173 B).

Garman's description of *P. amazonica* applies to *P. paræ*,

except that the dorsal origin is said to be a little in advance of that of anal.

3. *PÆCILIA PICTA*, sp. n. (Pl. C. figs. 1, 2, and Text-fig. 173 A.)

*Acanthophaelus melanzonus* (part.) Eigenm. Ann. Carnegie Mus. vi. 1909, p. 51; Mem. Carnegie Mus. v. 1912, p. 457, pl. lxiv, fig. 6.

♀. Depth of body  $3\frac{1}{2}$  to 4 in the length, length of head about 4. Diameter of eye  $3\frac{1}{2}$  to 4 in length of head, interorbital width  $1\frac{1}{2}$ . 26 to 29 scales in a longitudinal series. Dorsal 6-7, origin above middle or posterior part of anal and equidistant from base of pectoral and base of caudal; fin small, rounded. Anal 9-10, pointed. Pectoral  $\frac{3}{4}$  length of head; pelvics reaching vent or origin of anal. Least depth of caudal peduncle about  $\frac{2}{3}$  length of head. Olivaceous; sides of body with a dark brown spot on each scale and dark brown longitudinal stripes between the series of scales.

♂. Depth 3 to  $3\frac{1}{2}$  in the length. Dorsal origin nearly equidistant from eye and base of caudal; fin elevated. Least depth of caudal peduncle  $\frac{2}{3}$  to  $\frac{3}{4}$  length of head. Coloration sometimes as in female, but usually there are a few large dark spots on posterior part of body; dorsal fin usually with blackish spots; often an ocellus on upper part of base of caudal fin.

Demerara.

Numerous examples, the females measuring up to 45 mm., the males to 30 mm. in total length, presented in 1872 by F. G. Beckford, Esq.

*A. melanzonus* is based on a male of *Lebistes reticulatus* (type) and several females of *P. picta*.

In this species the intromittent organ differs somewhat from that of *P. vivipara*, but is formed on the same plan (text-fig. 173 A, C).

4. *PÆCILIA BRANNERI*.

*Pæcilia branneri* Eigenm. Ann. N.Y. Acad. vii. 1894, p. 629.

*Pæcilia heteristia* Regan, Ann. Mag. Nat. Hist. (8) iii. 1909, p. 235.

♀. Depth of body  $3\frac{1}{2}$  in the length, length of head 4. Diameter of eye  $3\frac{1}{2}$  in length of head, interorbital width nearly 2. 27 or 28 scales in a longitudinal series. Dorsal 6-7; origin above middle of anal and nearly equidistant from base of pectoral and base of caudal. Anal 8, pointed. Pectoral  $\frac{3}{4}$  length of head; pelvics extending to origin of anal. Least depth of caudal peduncle  $\frac{2}{3}$  length of head. Olivaceous; edges of scales darker; some blackish vertical streaks on the side and a blackish spot or vertical bar at base of caudal fin.

♂. Dorsal origin equidistant from middle of operculum and base of caudal; two last rays produced into long filaments. Caudal spot larger than in ♀; sometimes a blackish stripe near upper edge of caudal fin.

Para.

Here described from the types of *P. heteristia*, ♂ and ♀, each 35 mm. in total length.

The intromittent organ is very like that of *P. vivipara*, but the anterior branch of the second ray has fewer segments, as in *P. picta*.

#### 24. LEBISTES Filippi, 1861.

Arch. Zool. Anat. Fisiol. i. p. 69.

*Acanthophaecelus* Eigenmann, Proc. U.S. Nat. Mus. xxxii. 1907, p. 426, fig. 1.

Differs from *Pœcilia* only in that the third prolonged anal ray of the male has its last segments modified into a pair of projections which are directed obliquely outwards and towards the base of the fin.

A single species from South America.

LEBISTES RETICULATUS. (Text-fig. 173 D.)

*Pœcilia reticulata* Peters, Monatsb. Akad. Berlin, 1859, p. 412; Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 458.

*Lebistes pœcilioides* Filippi, Arch. Zool. Anat. Fisiol. i. 1861, p. 69, pl. iv. f. 6; Günth. Cat. Fish. vi. p. 356 (1866).

*Girardinus reticulatus* Günth. t. c. p. 352.

*Girardinus guppyi* Günth. t. c. p. 353; Regan, Proc. Zool. Soc. 1906, p. 390, pl. xxii. figs. 1, 1 a.

*Acanthophaecelus reticulatus* Eigenm. Proc. U.S. Nat. Mus. xxxii. 1907, p. 426, f. 1; Mem. Carnegie Mus. v. 1912, p. 458, pl. lxxv. figs. 1-3.

*Acanthophaecelus melanzonus* (part.) Eigenm. Mem. Carnegie Mus. v. 1912, p. 457, pl. lxxiv. fig. 5.

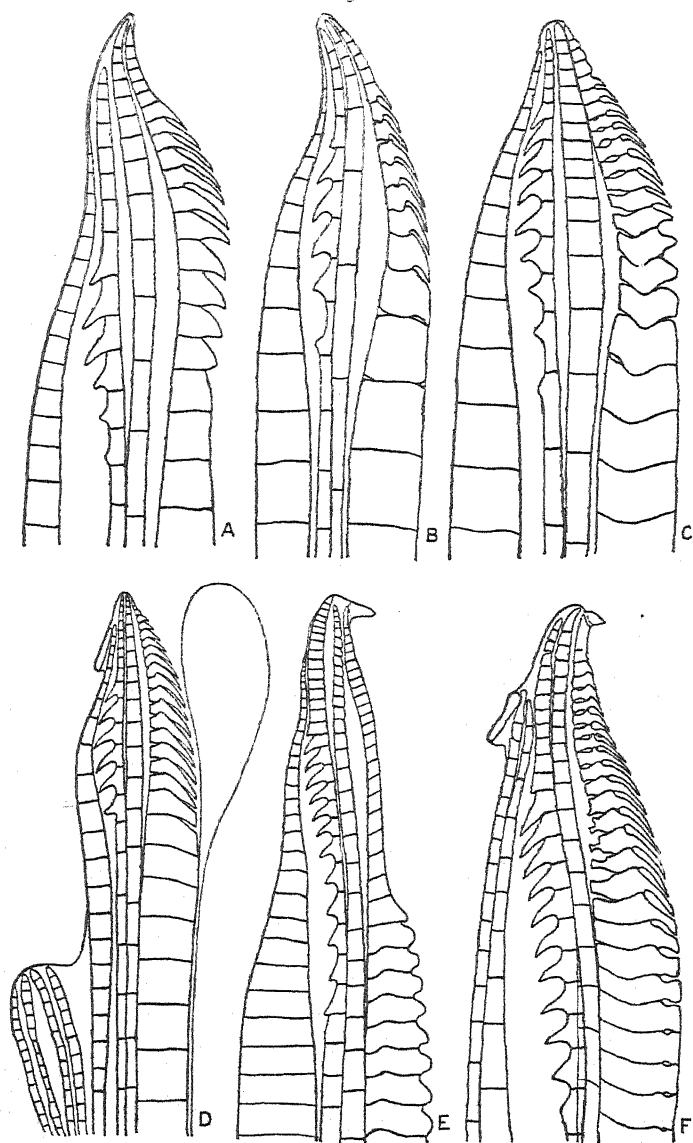
♀. Depth of body 3 to 4 in the length, length of head  $3\frac{2}{3}$  to  $4\frac{1}{2}$ . Diameter of eye 3 to  $3\frac{1}{2}$  in length of head, interorbital width  $1\frac{2}{3}$  to 2. 26 to 28 scales in a longitudinal series. Dorsal 7-8, rounded or obtuse; origin equidistant from eye or operculum and base of caudal. Anal 9-10, pointed; origin below or a little in advance of that of dorsal. Pectoral  $\frac{4}{5}$  length of head; pelvics extending to origin of anal. Least depth of caudal peduncle  $\frac{3}{4}$  to  $\frac{3}{2}$  length of head. Olivaceous; edges of scales darker, forming a network; fins immaculate, except sometimes a small dark spot on middle of caudal.

♂. Dorsal more elevated than in ♀, when laid back nearly reaching base of caudal fin; pelvics nearly as long as the short intromittent organ. Coloration very variable; often a blackish spot above or behind base of pectoral, another above anal fin or on middle of side, a third at base of caudal peduncle; often also several bluish-silvery spots, which may unite to form a lateral band, margined above and below by dark longitudinal stripes; dorsal and caudal sometimes spotted, often dark-edged.

Venezuela and St. Lucia to Santos.



Text-fig. 173.



Distal part of intromittent organ of :—A. *Pecilia picta*. B. *P. parae*. C. *P. vivipara*. D. *Lebistes reticulatus*. E. *Limia versicolor*. F. *Mollienisia sphenops*. The prepuce-like hood is indicated in fig. D.

In comparing with preceding figures note that these are reversed, the first prolonged ray being on the right, the third on the left.

Numerous examples, including co-types of the species received from the Berlin Museum and the types of *Girardinus guppyi*; females to 55 mm., males to 25 mm., in total length.

## 25. MOLLIIENISIA Le Sueur, 1821.

Journ. Acad. Philad. ii. p. 3; Günth. Cat. Fish. vi. p. 347 (1866); Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 49.

This genus differs from *Pacilia* in having a small antrorse spine at the end of the first prolonged ray of the male anal fin, as in *Limia*, and at the end of the third a paired process, probably the modified terminal segment, directed obliquely outwards and towards the base of the fin, as in *Lebistes* (text-fig. 173 F).

Some species hitherto referred to *Pacilia* (*M. sphenops*, *M. gracilis*) have an intromittent organ exactly similar to that of *Mollienisia latipinna* and *M. petenensis*, and as the little-known *M. formosa* is intermediate between the two groups in the size of the dorsal fin, all may be placed in *Mollienisia*. Some other species, with the dorsal fin further back than the anal, are provisionally included; all that is known of the males is Garman's statement that in *P. cuneata* the anal fin of the male is shorter than the head, indicating that the species is neither a *Paciliopsis* nor a *Girardinus*, although it may be a *Limia*.

### Synopsis of the Species.

- I. Dorsal 11-16; in adult males origin nearer end of snout than base of caudal, base longer than distance from caudal.
  - A. Caudal rounded or subtruncate (♀) or lower angle slightly produced (♂); scales 28 to 30. Dorsal 15-16 ..... 1. *petenensis*.
  - B. Caudal rounded; scales 26 to 28.
- Dorsal 14-16; in females origin equidistant from end of snout and base of caudal (young) or nearer snout (adult); base equal to (young) or more than (adult) distance from caudal ..... 2. *latipinna*.
- Dorsal 11-13; in females origin a little nearer base of caudal than end of snout, even in the adult; base equal to (adult) or less than (young) distance from caudal ..... 3. *formosa*.
- II. Dorsal 10-11; origin nearly equidistant from end of snout and base of caudal fin; base shorter than distance from caudal; anal origin below fourth ray of dorsal; scales 28 to 30 ..... 4. *gracilis*.
- III. Dorsal 7-11; origin nearly equidistant from end of snout and middle or posterior end of caudal fin; base shorter than distance from caudal.
  - A. Origin of anal below or a little behind that of dorsal ..... 5. *sphenops*.
  - B. Origin of anal in advance of that of dorsal.
- Dorsal 8-10. Anal 8-10. Scales 29-33 ..... 6. *elongata*.
- Dorsal 7-9. Anal 9-11. Scales 27-30 ..... 7. *occidentalis*.
- Dorsal 8. Anal 9. Scales 26 ..... 8. *spilurus*.

### 1. MOLLIIENISIA PETENENSIS.

Günth. Cat. Fish. vi. p. 348 (1866), and Trans. Zool. Soc. vi. 1868, p. 485, pl. lxxxvi. figs. 1-3; Regan, Biol. Centr.-Amer., Pisces, p. 106 (1907).

♀. Depth of body  $2\frac{2}{3}$  to 3 in the length, length of head 4. Diameter of eye  $\frac{1}{2}$  in length of head, interorbital width  $1\frac{3}{4}$ . 28 to 30 scales in a longitudinal series. Dorsal 15-16; base about as long as its distance from end of snout, longer than its distance from caudal fin; longest rays  $\frac{2}{3}$  or  $\frac{3}{4}$  length of head. Anal 9-10; origin below middle of dorsal. Pectoral as long as head; pelvics reaching origin of anal. Caudal rounded or subtruncate. Least depth of caudal peduncle nearly equal to length of head. A small spot on each scale, most conspicuous posteriorly; dorsal and caudal with series of small spots.

♂. Base of dorsal  $1\frac{1}{2}$  to  $1\frac{3}{4}$  its distance from end of snout and about twice its distance from caudal; longest rays longer than head. Anal below anterior part of dorsal; produced rays  $\frac{2}{3}$  length of head; second pelvic ray about as long. Lower angle of caudal slightly produced. Spots on lower part of dorsal forming undulating stripes; a series of large spots, one on each interradial membrane, along middle of fin. Lower margin of caudal blackish.

Lake Peten in Guatemala.

Three females, 100 to 110 mm., and three males, 100 to 130 mm. in total length, types of the species.

## 2. MOLLIENTISIA LATIPINNA.

Le Sueur, Journ. Acad. Philad. ii. 1821, p. 3, pl. iii.; Cuv. & Val. Hist. Nat. Poiss. xviii. p. 139, pl. 527; Günth. Cat. Fish. vi. p. 348 (1866); Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 50, pl. xii.; Jord. & Everm. Bull. U.S. Nat. Mus. xlvii. 1896, p. 699.

*Pœcilia multilineata* Le Sueur, t. c. p. 4.

*Pœcilia lineolata* Girard, U.S. Mex. Bound. Surv., Fish. p. 70, pl. xxxv. figs. 9-11 (1859).

*Limia pœcilioides* Girard, t. c. p. 70, pl. xxxviii. figs. 8-11; Proc. Acad. Philad. 1859, p. 115.

*Limia matamorensis* Girard, Proc. Acad. Philad. 1859, p. 116.

♀. Depth of body  $2\frac{2}{3}$  to 3 in the length, length of head  $3\frac{1}{2}$  to 4. Diameter of eye  $3\frac{1}{2}$  to 4 in length of head, interorbital width  $1\frac{1}{2}$  to 2. 26 to 28 scales in a longitudinal series. Dorsal 14-16; in adults base somewhat shorter than its distance from end of snout, longer than its distance from caudal; rays  $\frac{1}{2}$  length of head. Anal 9-10; origin below middle of dorsal. Pectoral a little shorter than head; pelvics reaching vent or origin of anal. Caudal rounded. Least depth of caudal peduncle about  $\frac{3}{4}$  length of head. Spots on scales forming longitudinal stripes; dorsal and basal part of caudal with series of small spots.

♂. Dorsal base, in adult, about  $1\frac{1}{2}$  its distance from end of snout or twice its distance from caudal; rays longer than head. Anal below anterior part of dorsal; produced rays  $\frac{3}{4}$  length of head, a little longer than second pelvic ray; caudal rounded. Spots on lower part of dorsal forming longitudinal stripes; a series of large spots, one on each interradial membrane, along middle of fin; caudal spotted superiorly, with blackish lower edge.

Southern United States.

Five females, 40 to 68 mm., and two males, 65 and 78 mm., from Pensacola and New Orleans.

### 3. MOLLIENTISIA FORMOSA.

*Limia formosa* Girard, Proc. Acad. Philad. 1859, p. 115.

*Mollientisia formosa*, Günth. Cat. Fish. vi. p. 349 (1866).

♀. Depth of body  $2\frac{1}{2}$  to 3 in the length, length of head  $3\frac{1}{3}$  to 4. Diameter of eye 3 to  $3\frac{1}{2}$  in length of head, interorbital width  $1\frac{3}{4}$  to 2. 26 to 28 scales in a longitudinal series. Dorsal 11-14; origin a little nearer to base of caudal than to end of snout; base, in adult, nearly equal to its distance from caudal, but less than its distance from head; longest rays  $\frac{1}{2}$  to  $\frac{2}{3}$  length of head. Anal 9-10; origin below fourth ray of dorsal. Pectoral a little shorter than head; pelvics reaching vent or origin of anal. Caudal rounded. Least depth of caudal peduncle  $\frac{3}{4}$  to  $\frac{2}{3}$  length of head. A spot on each scale; dorsal usually spotted.

♂. Dorsal origin nearer to end of snout than to base of caudal; base as long as its distance from eye; longest rays nearly  $\frac{3}{4}$  length of head.

Atlantic slope of Mexico and Central America.

Several small specimens (♂ and ♀) up to 45 mm. from Tampico (Jordan). Also three large females, 65 to 80 mm. in total length, from Colon (Rachow); these are structurally similar to the others, but have the coloration obscured by blackish mottling.

### 4. MOLLIENTISIA GRACILIS, nom. nov.

*Poecilia petenensis* (non *Mollientisia petenensis* Günth.) Günth. Cat. Fish. vi. p. 342, and Trans. Zool. Soc. vi. 1868, p. 484, pl. lxxxv. figs. 3, 4.

♀. Depth of body 4 to  $4\frac{1}{2}$  in the length, length of head  $4\frac{2}{3}$  to  $4\frac{4}{5}$ . Diameter of eye  $3\frac{1}{2}$  to  $3\frac{3}{4}$  in length of head, interorbital width 2. 28 to 30 scales in a longitudinal series. Dorsal 10-11; origin equidistant from præorbital and base of caudal; anterior branched rays  $\frac{2}{3}$  length of head. Anal 8-10, acutely pointed; origin below fourth ray of dorsal. Pectoral as long as head. Least depth of caudal peduncle  $\frac{3}{4}$  length of head. Olivaceous; scales dark-edged; dorsal and caudal speckled.

♂. Depth  $3\frac{1}{3}$  to  $3\frac{3}{4}$  in length; depth of caudal peduncle equal to length of head. Dorsal origin equidistant from end of snout and base of caudal; posterior rays longest, as long as or longer than head.

Lake Peten in Guatemala.

Two females, 120 and 150 mm. and three males, 95 to 120 mm. in total length, types of the species.

### 5. MOLLIENTISIA SPHENOPS. (Text-fig. 173 F.)

*Poecilia sphenops* Cuv. & Val. Hist. Nat. Poiss. xviii. p. 130, pl. 526 (1846); Regan, Biol. Centr.-Amer., Pisces, p. 102, pl. xiii. (1907) (with synonymy).

*Girardinus caucanus* Steind. Denkschr. Akad. Wien, xlii. 1880, p. 87, pl. vi. figs. 4, 5.

*Pecilia salvatoris* Regan, Ann. Mag. Nat. Hist. (7) xix. 1907, p. 65; Biol. Centr.-Amer., Pisces, p. 104, pl. xiv. figs. 2, 3 (1907).

*Pecilia amates* Miller, Bull. Amer. Mus. xxiii. 1907, p. 108.

? *Platypecilus tropicus* Meek, Publ. Columbian Mus., Zool. vii. 1907, p. 146.

*Pecilia tenuis* Meek, t. c. p. 147.

*Pecilia spilonota* Regan, Ann. Mag. Nat. Hist. (8) ii. 1908, p. 460.

♀. Depth of body  $2\frac{1}{2}$  to 4 in the length, length of head  $3\frac{1}{3}$  to  $4\frac{3}{4}$ . Diameter of eye 3 to 4 in length of head, interorbital width  $1\frac{1}{2}$  to 2. 25 to 30 scales in a longitudinal series. Dorsal 8-11; origin equidistant from eye or operculum and base of caudal. Anal 8-10; origin below or a little behind that of dorsal. Pectoral as long as or shorter than head. Least depth of caudal peduncle equal to or less than length of head. Dark greenish to pale olivaceous; edges of scales sometimes darker; often a dark spot on each scale of side of body; sometimes narrow vertical bars on sides; dorsal and caudal sometimes immaculate, often with series of small spots, or with a dark basal spot which may extend over most or all of the fin.

♂. Dorsal further forward and more elevated; spots on sides rarely present, dark cross-bars often distinct.

Coasts and rivers from Sinaloa to Panama and from Tamaulipas to Colombia, Venezuela, and the Leeward Islands.

Numerous examples to 120 mm. in total length, from all parts of the range of the species.

#### 6. MOLLINIENSIA ELONGATA.

*Pecilia elongata* Günth. Cat. Fish. vi. p. 342, and Trans. Zool. Soc. vi. 1869, p. 484, pl. lxxxv. fig. 2; Regan, Biol. Centr.-Amer., Pisces, p. 102 (1907).

? *Pecilia cuneata* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 62.

Panama.

#### 7. MOLLINIENSIA OCCIDENTALIS.

*Heterandria occidentalis* Baird & Girard, Proc. Acad. Philad. 1853, p. 390.

*Pecilia occidentalis* Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 71; Regan, Biol. Centr.-Amer., Pisces, p. 102 (1907).

Pacific Coast Rivers from Arizona to Jalisco.

#### 8. MOLLINIENSIA SPILURUS.

*Pecilia spilurus* Günth. Cat. Fish. vi. p. 345 (1866); Regan, Biol. Centr.-Amer., Pisces, p. 101 (1907).

Mexico or Central America.

## 26. LIMIA Poey, 1855.

Mem. Cuba, i. p. 383.

*Acropœcilia* Hilgendorf, Sitzungsab. Ges. Nat. Freund. 1889, p. 52.

This genus is well marked off from *Pœcilia* by the structure of the intromittent organ (text-fig. 173 E). At some distance from its end the first produced ray becomes abruptly slender; the distal part is not serrated, and near its extremity it bears an antrorse spine; the second and third produced rays are nearly as in *Pœcilia*. As in *Pœcilia*, the intromittent organ is short, usually shorter than the head, and its extremity is protected anteriorly by a cutaneous hood; in fully adult males the second pelvic ray is more or less prolonged.

Of eight species seven are from Cuba, Haiti, and Jamaica, and one from Venezuela. I have examined adult males in all but *L. ornata*.

*Synopsis of the Species.*

- I. Origin of dorsal fin about equidistant from middle of eye and base of caudal; origin of anal below fifth ray of dorsal ..... 1. *vittata*.
- II. Origin of dorsal nearer to base of caudal than to eye.
  - A. Origin of anal below anterior part of dorsal.
    - Dorsal 8-9; length of head  $3\frac{2}{3}$  to 4 in length of fish ..... 2. *dominicensis*.
    - Dorsal 10; length of head  $3\frac{2}{3}$  to 4 in length of fish ..... 3. *nigrofasciata*.
    - Dorsal 10-11; length of head 3 to  $3\frac{1}{2}$  in length of fish ..... 4. *arnoldi*.
  - B. Origin of anal below or very slightly in advance of that of dorsal.
    1. Length of head  $\frac{2}{3}$  length of fish (in adults of 50 mm.); a lateral series of dark bars in both sexes.
      - Interorbital width less than  $\frac{1}{2}$  length of head ..... 5. *ornata*.
      - Interorbital width  $\frac{1}{2}$  length of head, or more ..... 6. *caudofasciata*.
    2. Length of head less than  $\frac{1}{2}$  length of fish (in a specimen of 43 mm.). ♂ with 3 or 4 blackish cross-bars, ♀ with a blackish lateral stripe anteriorly ..... 7. *heterandria*.
  - C. Origin of anal always distinctly in advance of that of dorsal; head  $\frac{1}{4}$  length of fish (in adults of 50-60 mm.). 8. *versicolor*.

1. LIMIA VITTATA.

*Pœcilia vittata* Guichenot in Ramon de la Sagra, Hist. Nat. Cuba, Poiss. p. 146, pl. v. fig. 1 (1850); Günth. Cat. Fish. vi. p. 339 (1866); Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 58.

*Limia cubensis* Poey, Mem. Cuba, i. p. 388, pl. xxxi. figs. 12-13 (1855).

*Limia vittata* Poey, t. c. p. 389, pl. xxxi. figs. 14, 15.

?*Platypœcilus perugiae* Evermann & Clark, Proc. U.S. Nat. Mus. xxx. 1906, p. 851, fig.

♀. Depth of body  $2\frac{1}{2}$  to 3 in the length, length of head  $3\frac{1}{2}$  to  $4\frac{2}{3}$ . Diameter of eye 3 to  $3\frac{1}{2}$  in length of head, interorbital width  $1\frac{1}{2}$  to 2. 26 to 28 scales in a longitudinal series. Dorsal

9-11; origin nearly equidistant from middle of eye and base of caudal; branched rays subequal, or the middle ones the longer,  $\frac{2}{5}$  or  $\frac{3}{4}$  length of head. Anal 10; origin below fifth ray of dorsal. Pectoral  $\frac{3}{4}$  length of head or more; pelvics reaching vent. Least depth of caudal peduncle  $\frac{2}{5}$  to  $\frac{3}{4}$  length of head. Olivaceous; edges of scales darker; often a dark lateral band or 1 to 3 series of dark spots along the series of scales on middle of side; dorsal and caudal usually with small dark spots.

♂. Dorsal origin equidistant from snout and base of caudal; posterior rays longest, longer than head in the adult. Intromittent organ a little shorter than head; second pelvic ray produced, inner rays ending in a knob. Least depth of caudal peduncle nearly equal to length of head. Usually dark cross-bars on body; spots on dorsal and caudal fins larger and blacker than in females.

Cuba; ? San Domingo.

Several specimens from Cuba, the males 45 to 70, the females 40 to 100 mm., in total length.

## 2. LIMIA DOMINICENSIS.

*Pecilia dominicensis* Cuv. & Val. Hist. Nat. Poiss. xviii. p. 131, pl. 526. fig. 1 (1846).

*Pecilia melanogaster* Günth. Cat. Fish. vi. p. 345 (1866).

*Platyptocilus dominicensis* Evermann & Clark, Proc. U.S. Nat. Mus. xxx. 1906, p. 852, fig.

Depth of body  $2\frac{1}{2}$  to 3 in the length, length of head  $3\frac{2}{3}$  to 4. Diameter of eye 3 to  $3\frac{1}{3}$  in length of head, interorbital width  $1\frac{1}{2}$ . 26 or 27 scales in a longitudinal series. Dorsal 8-9; origin equidistant from occiput or operculum and base of caudal, or tip of snout and end of caudal, first or second branched ray longest,  $\frac{2}{3}$  length of head. Anal 10; origin below second or third ray of dorsal; anterior branched rays longest. Pectoral  $\frac{3}{4}$  length of head; pelvics reaching vent. Least depth of caudal peduncle  $\frac{2}{5}$  to  $\frac{3}{4}$  length of head. Olivaceous; sometimes traces of dark bars on upper part of sides and of a dark spot at base of caudal; a blackish spot on basal part of posterior  $\frac{1}{2}$  of dorsal fin; ripe females with abdomen golden in front, blackish behind, the two colours separated by a ventral line at insertion of pelvic fins.

San Domingo; ? Jamaica.

Seven specimens; two of the types of the species, ♂ and ♀, 38 and 42 mm. in total length, and five females of 50 to 60 mm., types of *P. melanogaster*.

## 3. LIMIA NIGROFASCIATA, sp. n. (Pl. CI. figs. 1, 2.)

♀. Depth of body  $2\frac{1}{2}$  to 3 in the length, length of head  $3\frac{2}{3}$  to 4. Diameter of eye  $3\frac{1}{2}$  to  $3\frac{2}{3}$  in length of head, interorbital width  $1\frac{1}{2}$ . 27 or 28 scales in a longitudinal series. Dorsal 10; origin equidistant from middle of operculum and base of caudal; fin rounded, the longest rays  $\frac{1}{2}$  length of head. Anal 9, obtuse:

origin below anterior  $\frac{1}{4}$  of dorsal. Pectoral  $\frac{2}{3}$  length of head; pelvics not or barely reaching vent. Least depth of caudal peduncle  $\frac{2}{3}$  or  $\frac{3}{4}$  length of head. Body with 7 to 9 blackish vertical bars; a dark spot near base of posterior part of dorsal.

♂. Depth  $2\frac{1}{4}$  to  $2\frac{1}{2}$  in the length. Dorsal origin equidistant from eye or preoperculum and base of caudal; longest rays  $\frac{2}{3}$  length of head, or in adult nearly as long as head.

Miragoâne, Haiti.

Two females, 43 mm. in total length, an immature male of 41 mm., and an adult male of 48 mm., presented by Messrs. J. Paul Arnold and A. Rachow.

#### 4. *LIMIA ARNOLDI*, sp. n. (Pl. CI. fig. 5.)

♀. Depth of body 3 to  $3\frac{2}{3}$  in the length, length of head 3 to  $3\frac{1}{2}$ . Diameter of eye 3 to  $3\frac{1}{2}$  in the length of head, interorbital width 2. 26 or 27 scales in a longitudinal series. Dorsal 10-11; origin equidistant from postorbital part of head and base of caudal; fin rounded, the longest rays  $\frac{1}{2}$  length of head. Anal 9-10, rounded or obtusely pointed; origin below anterior part of dorsal. Pectoral  $\frac{3}{4}$  length of head; pelvics extending to vent. Least depth of caudal peduncle  $\frac{1}{2}$  to  $\frac{2}{3}$  length of head. Body with 8 to 12 narrow dark vertical bars; dorsal sometimes spotted, often with a small dark spot posteriorly near its base.

♂. Depth of body 3 in the length. Dorsal origin equidistant from eye and base of caudal; longest rays  $\frac{2}{3}$  length of head. Intromittent organ  $\frac{1}{4}$  length of fish (to base of caudal); second pelvic ray stout, a little produced beyond third and fourth, which are truncated distally. Least depth of caudal peduncle  $\frac{3}{4}$  length of head. No dark vertical bars, but several series of vertically expanded spots.

Miragoâne, Haiti.

Ten females, 26 to 42 mm. in total length, and three males of 28 to 38 mm., presented by Herr J. Paul Arnold.

#### 5. *LIMIA ORNATA*, sp. n. (Pl. CI. fig. 7.)

Depth of body  $3\frac{1}{2}$  to 4 in the length, length of head 3 to  $3\frac{1}{2}$ . Diameter of eye  $3\frac{1}{2}$  to 4 in length of head, interorbital width  $2\frac{1}{2}$  to  $2\frac{1}{2}$ . 28 scales in a longitudinal series. Dorsal 8-10; origin equidistant from some part of operculum and base of caudal; fin rounded, the longest rays  $\frac{1}{2}$  length of head. Anal 10; origin below that of dorsal. Pectoral  $\frac{2}{3}$  or  $\frac{3}{4}$  length of head; pelvics reaching vent or origin of anal. Least depth of caudal peduncle  $\frac{2}{3}$  the length of head. Head, body, and usually vertical fins with blackish spots more or less developed; body also with a series of dark bars or large vertically expanded spots.

Haiti.

Five females, 31 to 55 mm. in total length, presented by Herr J. Paul Arnold.



6. *LIMIA CAUDOFASCIATA*, sp. n. (Pl. CI. fig. 6.)

♀. Depth of body 3 to  $3\frac{1}{2}$  in the length, length of head 3 to  $3\frac{1}{2}$ . Diameter of eye  $3\frac{1}{4}$  to  $3\frac{1}{2}$  in length of head, interorbital width  $1\frac{1}{5}$  to 2. 26 scales in a longitudinal series. Dorsal 8-10; origin equidistant from some part of operculum and base of caudal; anterior branched rays longest,  $\frac{1}{2}$  length of head. Anal 10; origin below or a little in advance of that of dorsal. Pectoral  $\frac{3}{4}$  length of head; pelvics reaching vent. Least depth of caudal peduncle  $\frac{1}{2}$  to  $\frac{2}{3}$  length of head. Olivaceous or brownish; edges of scales darker; a series of dark vertical bars on posterior part of body; a dark spot near base of posterior part of dorsal; abdomen yellowish, or when tumid golden anteriorly and blackish posteriorly, as in *L. dominicensis*.

♂. Dorsal origin about equidistant from eye and base of caudal; longest rays  $\frac{1}{2}$  to  $\frac{2}{3}$  (adult) length of head. Intromittent organ less than  $\frac{1}{4}$  length of fish; second pelvic ray produced in adult, nearly as long as prolonged anal rays. Least depth of caudal peduncle  $\frac{2}{3}$  length of head.

Jamaica.

Several females, 28 to 42 mm. in total length, and six males of 25 to 48 mm., collected by C. A. Wray. In males of 25 to 30 mm., the anal fin has not attained the adult structure and the second pelvic ray is scarcely prolonged; males of 35 to 48 mm. have the anal fully formed, but only the largest has the pelvics strongly produced.

7. *LIMIA HETERANDRIA*, sp. n. (Pl. CI. figs. 3, 4.)

♀. Depth of body  $3\frac{1}{2}$  in the length, length of head  $3\frac{2}{3}$  to  $4\frac{1}{4}$ . Diameter of eye 3 to  $3\frac{1}{2}$  in length of head, interorbital width 2. 26 scales in a longitudinal series. Dorsal 8; origin equidistant from some part of operculum and base of caudal; fin rounded, longest rays a little more than  $\frac{1}{2}$  length of head. Anal 9, pointed; origin below that of dorsal. Pectoral  $\frac{3}{4}$  length of head; pelvics reaching vent. Least depth of caudal peduncle  $\frac{1}{2}$  or  $\frac{2}{3}$  length of head. Olivaceous; a dark longitudinal stripe from above pectoral to level of origin of anal; a dark spot above vent; a black spot near base of posterior part of dorsal.

♂. Dorsal origin equidistant from middle of eye and base of caudal; longest rays  $\frac{3}{5}$  length of head. Intromittent organ about  $\frac{2}{3}$  length of fish (to base of caudal); second ray produced,  $\frac{3}{4}$  as long as prolonged anal rays. Stripe on side of body and spot above vent absent; body with 3 or 4 narrow dark vertical bars.

La Guayra, Venezuela.

Two females, 43 and 27 mm., and a male of 25 mm. (adult), presented by Herr J. Paul Arnold.

8. *LIMIA VERSICOLOR*. (Text-fig. 173 E.)

*Pecilia dominicensis* (non Cuv. & Val.) Günth. Cat. Fish. vi.

p. 346 (1866); Garman, Mem. Mus. Comp. Zool. xix. 1895, p. 57.

*Girardinus versicolor* Günth. t. c. p. 352.

*Acropocilia tridens* Hilgendorf, Sitzungsab. Naturf. Freunde, 1889, p. 52.

♀. Depth of body 3 to 4 in the length, length of head  $3\frac{1}{2}$  to 4. Diameter of eye 3 to  $3\frac{1}{2}$  in length of head; inter-orbital width  $1\frac{3}{4}$  to 2. 26 to 28 scales in a longitudinal series. Dorsal 7-9; origin equidistant from some part of operculum and base of caudal: middle rays longest, about  $\frac{3}{5}$  the length of head. Anal 8-10; origin a little in advance of that of dorsal. Pectoral a little shorter than head; pelvics about reaching vent. Least depth of caudal peduncle  $\frac{3}{5}$  to  $\frac{5}{8}$  the length of head. Olivaceous, edges of scales darker; an indistinct lateral band or a series of short vertical bars; sometimes irregular dark spots on the back; a blackish spot on base of posterior part of dorsal; caudal sometimes with vertical bands.

♂. In specimens of 30 mm. dorsal and pelvic fins as in ♀, but in those of 40 to 45 mm. dorsal more elevated, the longest rays  $\frac{3}{4}$  length of head, second pelvic ray somewhat produced and inner pelvic rays expanded and truncated at ends.

San Domingo.

Ten females, 35 to 60 mm., including the types of the species, and four males, 30-45 mm.

## EXPLANATION OF THE PLATES.

### PLATE XCIX.

- Figs. 1, 2. *Gambusia oligosticta*, ♀ & ♂.  
 3, 4. " *wrayi*, ♀ & ♂.  
 5, 6. " *gracilior*, ♀ & ♂.  
 7. " *dominicensis*, ♀.

### PLATE C.

- Figs. 1, 2. *Pacilia picta*, ♀ & ♂.  
 3, 4. *Paciliopsis isthmensis*, ♀ & ♂.  
 5, 6. *Phalloceros caudomaculatus*, ♀ & ♂.  
 7, 8. *Phalloptychus januarius*, ♀ & ♂.

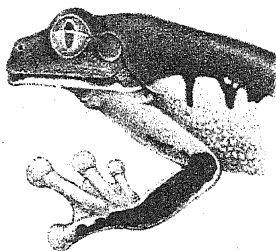
### PLATE CI.

- Figs. 1, 2. *Limia nigrofasciata*, ♀ & ♂.  
 3, 4. " *heterandria*, ♀ & ♂.  
 5. " *arnoldi*, ♀.  
 6. " *caudofasciata*, ♂.  
 7. " *ornata*, ♀.

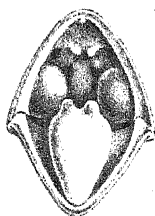




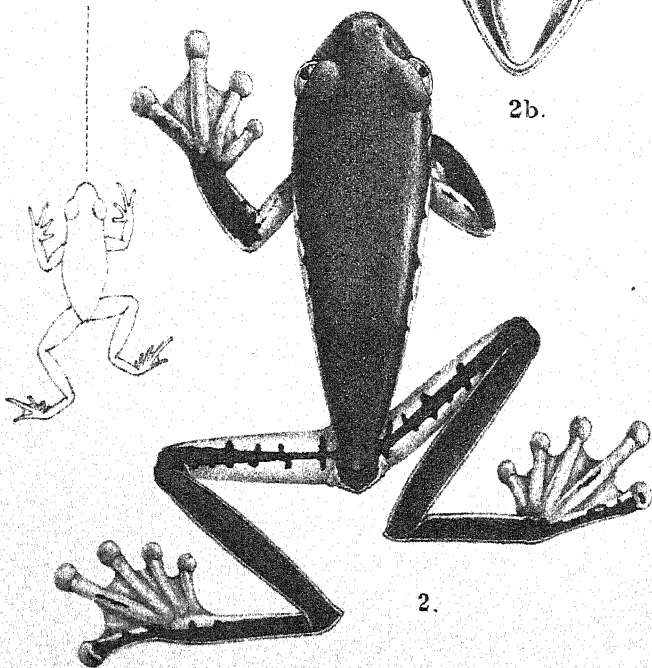
1.



2a.



2b.



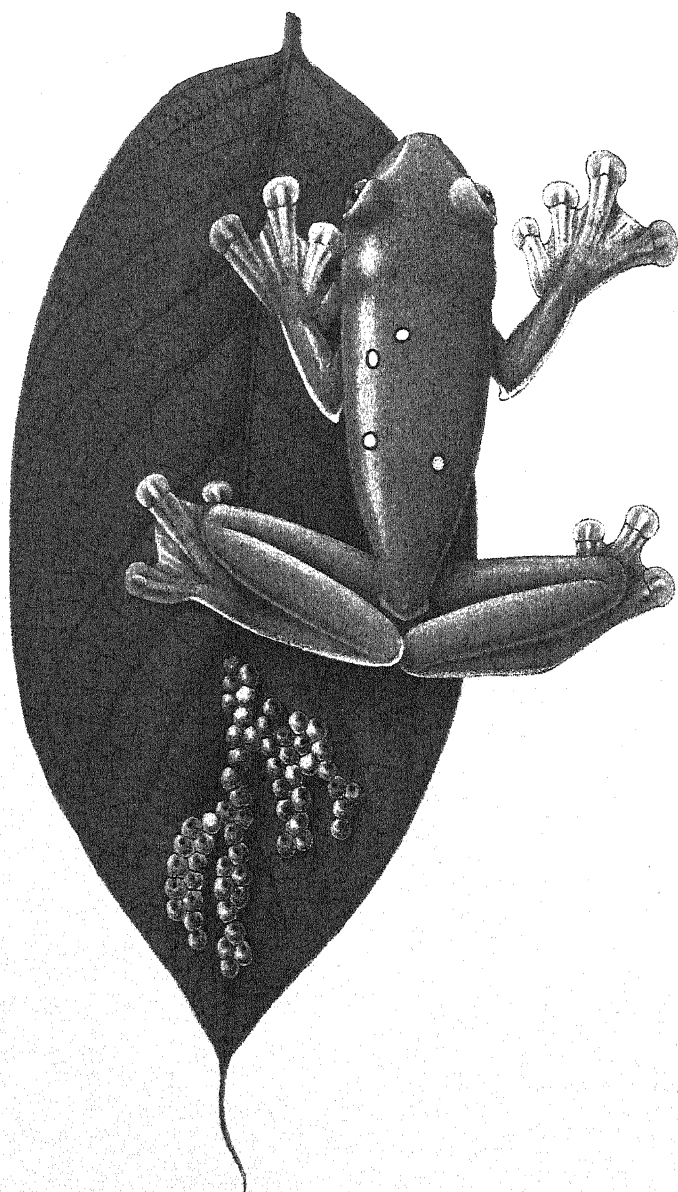
2.

1. BUFO HYPOMELAS.

2. AGALYCHNIS CALCARIFER.

J. Green del. et lith.





AGALYCHNIS SPURRELLI.

J. Green del et Chromo.





1.



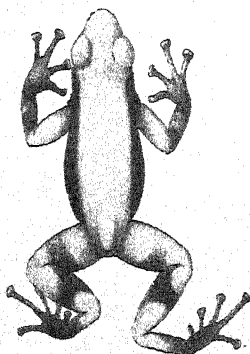
4.



2.



3.



5.



6.

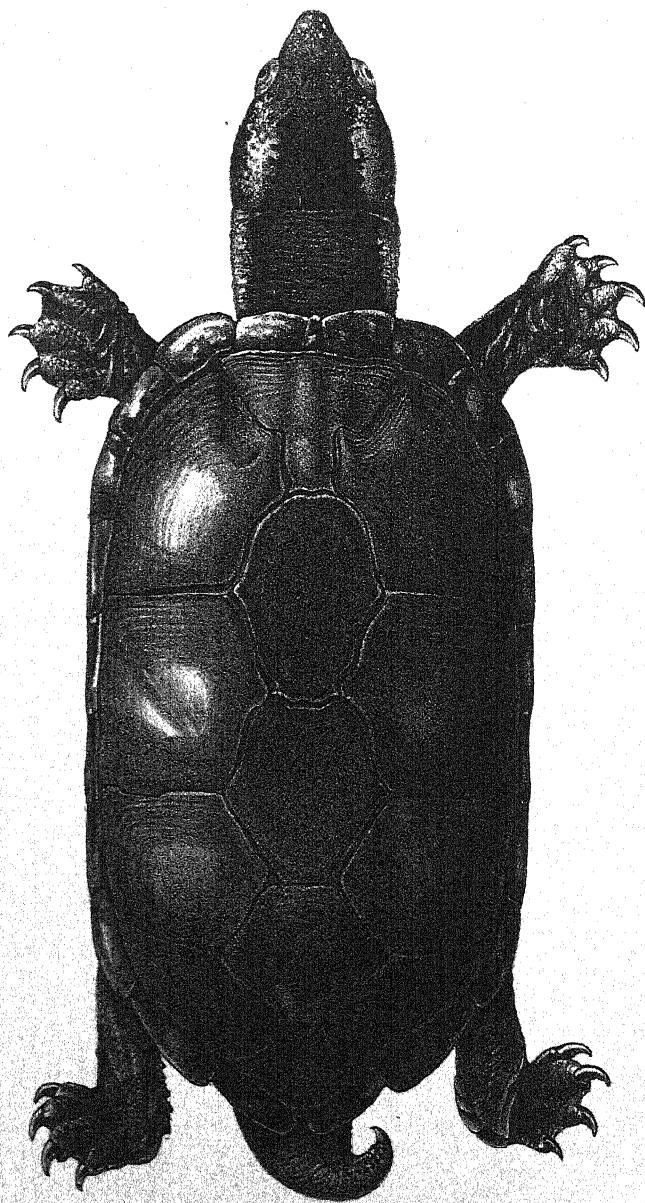
J. Green del. et Chromo.

1. DENDROBATES AUROTÆNIA.

2-4. D. TINCTORIUS, VAR. COCTÆI. 5-6. D. TINCTORIUS, VAR. CHOCOENSIS.

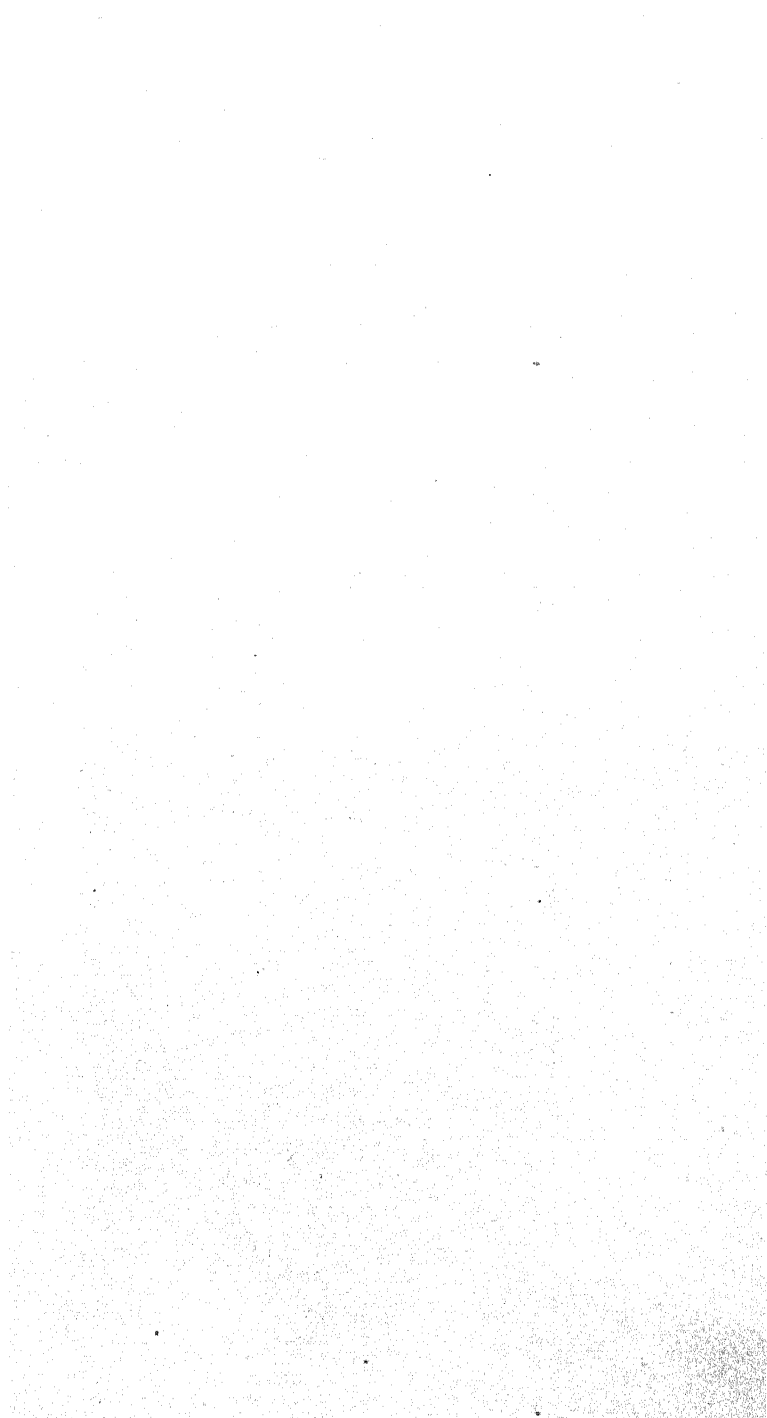


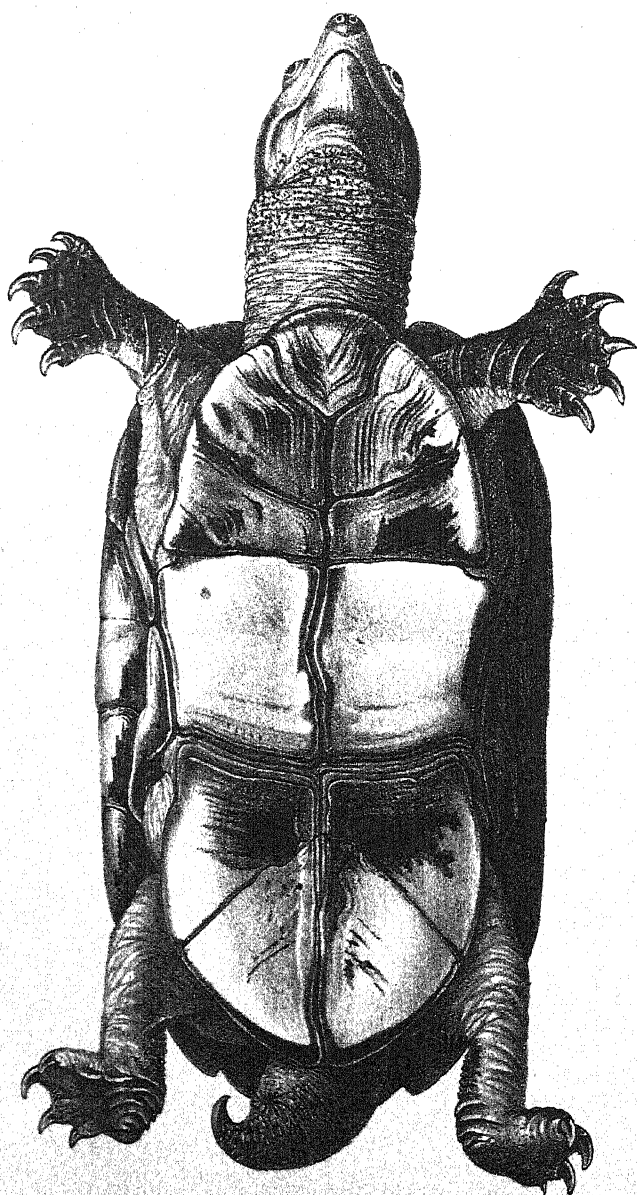




CINOSTERNUM SPURRELLI.

J. Green del. et lith.

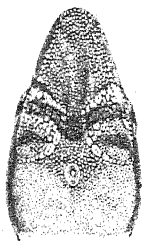




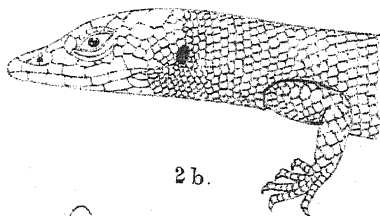
CINOSTERNUM SPURRELLI.

J. Green del. et lith.





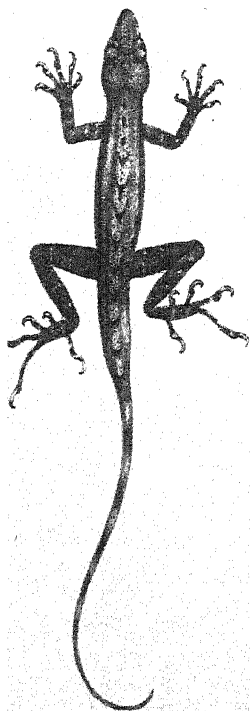
1b.



2b.



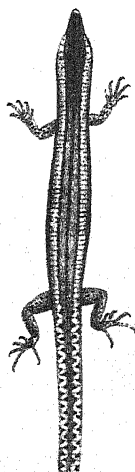
2a.



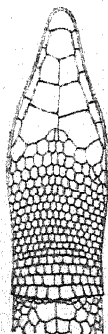
1.



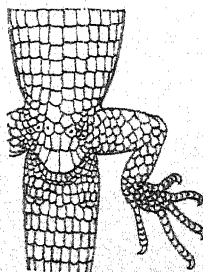
1a.



2.



2d.



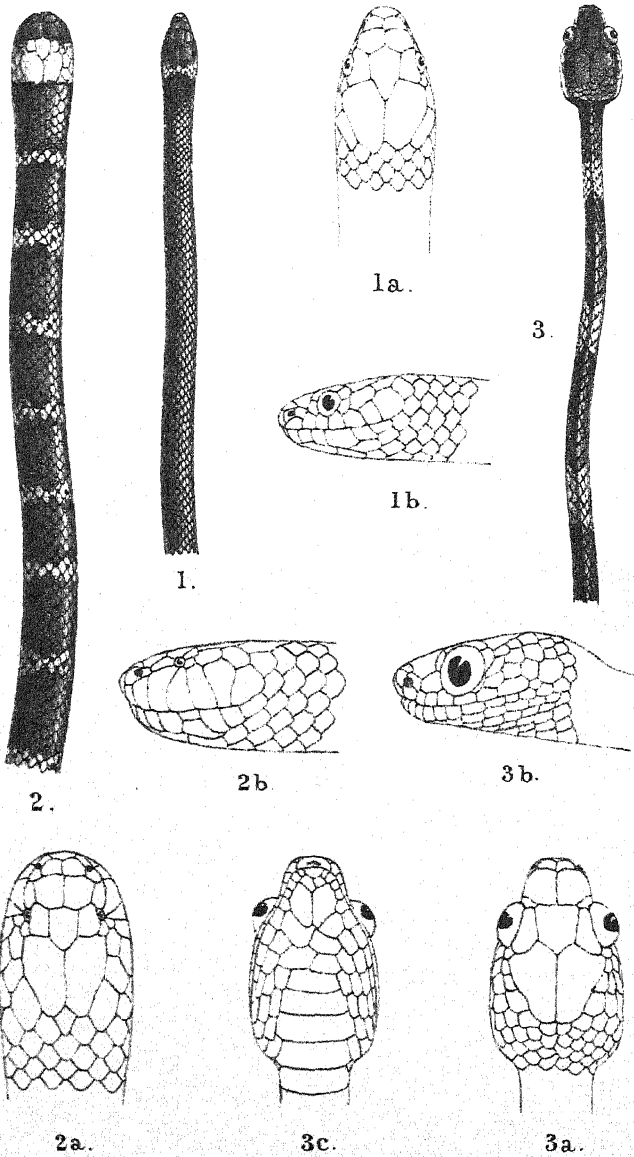
2c.

J. Green del. et lith.

1. ANOLIS BREVICEPS.

2. ANADIA VITTATA.





J. Green del. et lith.

1. HOMALOCRANIUM CORALLIVENTRE. 2. ELAPS MICROPS  
3. LEPTOGNATHUS SPURRELLI.



59. On a Collection of Batrachians and Reptiles made by  
Dr. H. G. F. Spurrell, F.Z.S., in the Choco, Colombia.  
By G. A. BOULENGER, F.R.S., F.Z.S.\*

[Received October 10th, 1913: Read November 11th, 1913.]

(Plates CII.-CVIII.† and Text-figures 174-178.)

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" <i>palmeri</i> .....	1021
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Dr. Spurrell, to whom the Zoological Society is indebted for so many interesting additions to its collection of Reptiles, has now transferred his activity as a collector from West Africa to South America. The series of beautifully preserved Batrachians and Reptiles brought together by him during the first few months of his stay in the Choco, Colombia, and presented by him to the British Museum, is one of great interest and shows how much remains to be done in the exploration of that part of South America. Unless otherwise stated, the specimens are from Peña Lisa, Condoto, altitude 300 feet. Within the last few years, series of Batrachians and Reptiles brought together by Mr. M. G. Palmer in the same district had been acquired by the Trustees of the British Museum and furnished the types of several new species described by me‡. They showed a close agreement with the fauna of N.W. Ecuador, for a knowledge of which we are indebted chiefly to Mr. Rosenberg §—an agreement which is further exemplified by Dr. Spurrell's collection.

\* Published by permission of the Trustees of the British Museum.

† For explanation of the Plates see p. 1038.

‡ Ann. & Mag. N. H. (8) ii. 1903, p. 515, and vii. 1911, p. 19.

§ Boulenger, P. Z. S. 1898, p. 107, and Ann. & Mag. N. H. (7) ix. 1902, p. 51.

## BATRACHIA.

## APODA.

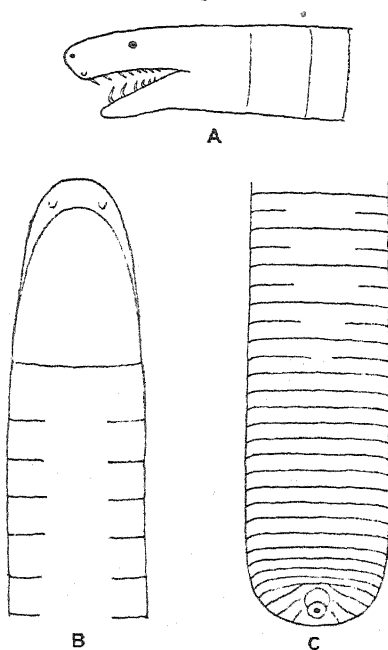
1. *CÆCILIA ISTHMICA* Cope.

Known from the Isthmus of Darien and Western Ecuador.

2. *CÆCILIA INTERMEDIA*, sp. n. (Text-fig. 174.)

Intermediate between *C. tentaculata* L. and *C. pachynema* Gthr. Snout as in the former, more strongly projecting than in the latter. Outer mandibular teeth larger than in the former and smaller than in the latter. Snout rounded, very prominent, as long as the distance between the eyes; tentacle on the lower surface of the snout, nearer the edge of the mouth than the

Text-fig. 174.

*Caecilia intermedia.*

- A. Side view of head. B. Lower view of head and anterior extremity of body.  
C. Lower view of posterior extremity of body.

nostril. Body cylindrical, its diameter 43 to 56 times in the total length. 200 to 250 circular folds, mostly widely interrupted on the back and on the belly; from the posterior fourth of the body short intermediate folds appear and gradually extend across the back; the last 60 to 80 folds close together and complete on the back, the 15 to 30 hindermost completely encircling the body. Uniform blackish; head of young yellowish or pale brown.

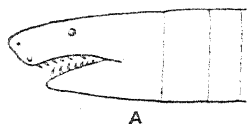
I have examined six specimens of this species, which was

first discovered in N.W. Ecuador by one of Mr. Rosenberg's collectors:—

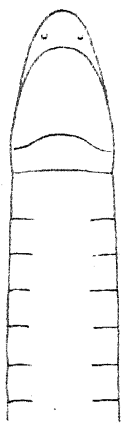
1. S. Javier, N.W. Ecuador.—Total length 950 mm., diameter of body 17.
2. Paramba, N.W. Ecuador, 3500 ft.—Total length 820 mm., diameter of body 19.
3. Pambelar, N.W. Ecuador.—Total length 690 mm., diameter of body 12.
4. Peña Lisa, Condoto, Choco (had been swallowed by an *Elaps rosenbergii* 940 mm. long).—Total length 690 mm.; diameter of body 13\*.
5. Same locality (taken from the stomach of a *Streptophorus atratus* swallowed by an *Elaps corallinus*).—Total length 280 mm.; diameter of body 6.
6. Same locality.—Total length 270 mm.; diameter of body 5.

I avail myself of this opportunity to define a further species, from a collection made in the Choco by Mr. M. G. Palmer, recently acquired by the British Museum:—

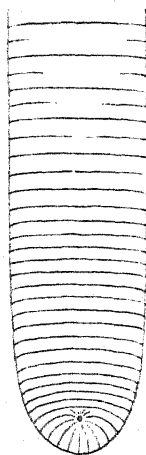
*Cecilia palmeri*, sp. n. (Text-fig. 175.)—Head and dentition as Text-fig. 175.



A



B



C

*Cecilia palmeri*.

Lettering as in text-fig. 174.

\* The copulatory organ of this specimen is extruded; it measures 10 mm. in length and terminates in a four-lobed "glans."

in *C. pachynema*. Diameter of body 58 times in total length, 200 circular folds, mostly interrupted on the back and belly; from the posterior fourth of the body short interrupted folds appear and gradually extend across the back; the last 95 folds close together and complete on the back, the 16 hindermost completely encircling the body. Uniform blackish. Total length 700 mm.; diameter of body 12.

A single specimen from Novita, Rio San Juan, 200 ft.

### 3. *CECILIA NIGRICANS* Blgr.

Described in 1902 from a single specimen from the Rio Lita, N.W. Ecuador.

The specimen in Dr. Spurrell's collection measures 395 mm., diameter of body 7.

## ECAUDATA.

### 4. *BUFO HYPOMELAS*, sp. n. (Pl. CII. fig. 1.)

Crown without bony ridges; snout truncate, moderately prominent, with angular canthus and vertical loreal region; inter-orbital space as broad as the upper eyelid; tympanum moderately distinct, half diameter of eye. Fingers moderate, first not extending as far as second; toes short, barely half-webbed; subarticular tubercles feebly prominent, single; two small metatarsal tubercles; no tarsal fold. Tarso-metatarsal articulation reaching the tip of the snout. Skin smooth; parotoid gland narrow, shorter than the head. Black, elegantly marked with grey lines above, vermicular or ring-shaped; a whitish streak on each side in the lumbar region, and another on the arm; lower parts with small greyish-white spots.

From snout to vent 20 mm.

This small toad, represented by a single specimen from the upper waters of the Condo, altitude 1200 feet, differs from all its American congeners in the shortness of the inner finger.

### 5. *BUFO HEMATITICUS* Cope.

### 6. *BUFO MARINUS* L.

### 7. *BUFO TYPHONIUS* L.

Dr. Spurrell, in his notes, remarks: "Said to be the toad from which Indians extract arrow-poison." See further on, p. 1028.

### 8. *HYLA MAXIMA* Laur.

"Apparently strictly nocturnal. Pupil of eye at night large and round, in daylight diamond-shaped. One caught at night on top of partition between two rooms in bungalow was almost uniform chocolate-brown with a dark median streak from snout to middle of back. By daylight it turned to a light yellowish brown, with very pronounced markings of warm darker brown on

the body and limbs, greyer to sepia-brown on the head; a patch of lighter yellow across loins. Iris golden brown; lower eyelid veined with gold."

It is characteristic of this species to possess a rudiment of pollex appearing as a small tubercle in females and a larger tubercle in males. In the male sent by Dr. Spurrell, this pollex projects externally as a long sharp bony spine at right angles to the metacarpal of the inner finger and piercing the skin; whether this is due to the desiccation of the specimen, or occasionally happens during life as in the case of the pollex of *Rana holsti* or of the ends of the ribs in the *Pleurodele* Newt, I cannot say.

Text-fig. 176.



*Hyla maculosa*. Inner fingers of male.

#### 9. *HYLA BAUDINI* Daud.

When taken out of a dark hole these frogs are brown above, usually with a metallic-green streak along the upper lip. After exposure to light the colour changes to light yellowish grey, with small green spots on the back and bars on the hind limbs. One of the specimens, a female, is remarkable for the longer hind limbs, the tibio-tarsal articulation reaching beyond the tip of the snout.

These frogs were pairing on the 31st May.

Larvæ, at different stages of development, agree in essential characters with those of *H. arborea*: position of eyes, spiraculum and vent, shape of tail, structure of the mouth and lips. Three long series of teeth in each lip, the third of the upper lip interrupted, the others continuous; beak broadly edged with black. Total length 60 mm.; body 21; width of body 13; tail 39; depth of tail 16.

#### 10. *AGALYCHNIS CALCARIFER* Blgr. (Pl. CII. fig. 2.)

Described in 1902 from a single specimen from the Rio Durango, N.W. Ecuador, 350 feet.

The only example obtained by Dr. Spurrell is described in his notes as brilliant sage-green above, flanks and upper surface of thighs (with the exception of a narrow green streak) rich orange-yellow with black bars; hands and feet and lower parts orange-

yellow; iris grey, bordered with orange-yellow; lower eyelid transparent, edged with turquoise-blue.

11. *AGALYCHNIS SPURRELLI*, sp. n. (Pl. CIII.)

Tongue oval, feebly emarginate behind. Vomerine teeth in two strong, transverse or slightly oblique series on a level with the front edge of the rather large choana. Head moderately depressed, as long as broad or slightly broader than long; snout rounded, not projecting beyond the lower jaw; canthus rostralis feeble; loreal region concave and very oblique; interorbital space broader than the upper eyelid; tympanum close to the eye and two-thirds to three-fourths its diameter. Fingers much flattened and nearly entirely webbed, the disks nearly as large as the eye or about two-thirds its size; toes rather short, much flattened, entirely webbed (three-fourths webbed in the young), the disks a little smaller than those of the fingers; subarticular tubercles very prominent. The tibio-tarsal articulation reaches between the eye and the tip of the snout. Skin smooth, granular on the belly and on the basal half of the lower surface of the thigh; a regular series of granules extends along the whole length of the lower surface of the thigh; a narrow dermal fold along the outer edge of the forearm, the inner edge of the tarsus, and across the heel; a few scattered (white) flat warts on the back. Green above, the dorsal warts, two to nine in number and irregularly disposed, white, edged with violet-black; belly yellowish white; iris ruby-red; lower eyelid with an open meshwork of golden lines. Male without vocal sac, with a patch of black nuptial asperities on the upper surface of the inner finger.

From snout to vent 95 mm.

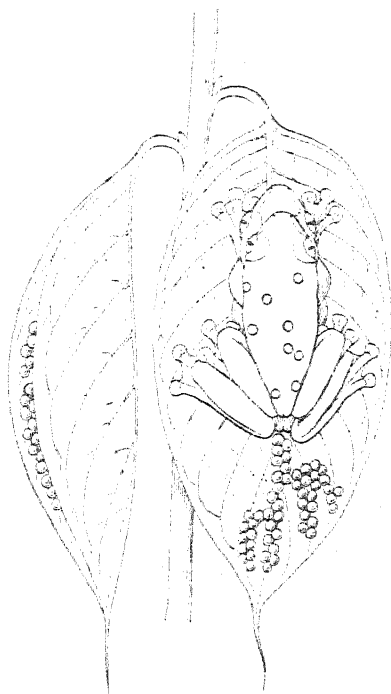
Very closely allied to the Central American *A. moreleti* A. Dum., this handsome frog differs in the more extensively webbed digits, the presence of white warts on the back, and the absence of vocal sac in the male.

Four specimens are in the collection. The first was reported to Dr. Spurrell to have been found at the top of a high tree that had been felled, on March 30th. On April 2nd Dr. Spurrell took a pair in embrace on a leaf overhanging a pool of water two feet below; from the sketch accompanying his notes, the amplexus is similar to that of *Hyla arborea*. The pair were in the act of breeding, and the eggs, as they were extruded, were being fixed to the upper surface of the terminal third of the leaf, in double rows following more or less regularly the venation, the very prominent ribs affording a support for their attachment. On the leaf sent with the specimens, the breeding operations of which were suddenly interrupted, 59 eggs are attached, and 7 more adhere to the right foot of the female, showing that she uses her feet for the purpose of fixing the eggs.

According to a sketch by Dr. Spurrell, which is here reproduced (text-fig. 177), another leaf on the same stalk was already entirely beset with eggs (laid by the same female?)

and folded over to form a nest as in *Phyllomedusa hypochondrialis*\*. The eggs resemble those of *Alytes obstetricans* in size (diameter 3 to 4 mm.) and in the tough gelatinous capsule, but differ in the upper pole being brown and in not being strung together.

Text-fig. 177.



*Agalychnis spurrelli* spawning.

The leaf, which I have not been able to get identified, probably belongs to the family Anonaceæ.

12. LEPTODACTYLUS PENTADACTYLUS Laur.

13. HYLDES PALMATUS Blgr.

14. HYLDES CONSPICILLATUS Gthr.

15. GLOSSOSTOMA ATERRIMUM Gthr.

Originally described from Costa Rica, this Engystomatid has since been found on the Río Durango, N.W. Ecuador.

\* Budgett, Q. J. Micr. Sci. xlii. (1899) p. 313, pl. xxviii.

The specimen in Dr. Spurrell's collection measures 55 mm. from snout to vent. It was shining jet-black in life, with the belly grey. The thick skin of the ventral region forms a strong fold on each side, which extends across the pubic region.

16. *RANA PALMIPES* Spix.

A single female specimen, measuring 95 mm. from snout to vent.

Tympanum three-fourths the diameter of the eye. First finger extending well beyond second. Skin of back finely granulate; upper surface of tibia with longitudinal ridges formed by confluent granules. Tibio-tarsal articulation reaching half-way between the eye and the tip of the snout. Back pale olive-grey (appears to have been green in life), without spots; belly uniform white.

I have examined smaller specimens (40 to 70 mm.) from the same locality (Comloto) from Mr. M. G. Palmer's collection. In the smallest the tympanum measures barely two-thirds the diameter of the eye, the upper parts are blackish brown and the lower parts profusely spotted with black.

17. *PHYLLOBATES PRATTI* Blgr.

A single specimen, 15 mm. long from snout to vent.

This species was described in 1899 (Ann. & Mag. N. H. [7] iii. p. 274, pl. xi. fig. 3) from two specimens obtained by Mr. A. E. Pratt at Santa Ines, north of Medellin, at an altitude of 3800 feet. Other specimens have since been found in the Choco, at Novita, altitude 150 feet, by Mr. M. G. Palmer. In Dr. Spurrell's specimen, the white line in front of the thigh is produced forward to the upper eyelid, dividing obliquely the black lateral band.

18. *DENDROBATES TINCTORIUS* Schneid. (Pl. CIV. figs. 2-6.)

The extraordinary colour variations to which this species is subjected are only paralleled by those of the African frogs of the genus *Rappia*, and afford the same difficulties to the systematist. Some of these variations are local, others are merely individual; great is the perplexity in having to decide which deserve to be recognised by a special varietal name. In the collection made by Dr. Spurrell the specimens fall under two principal categories which I will designate as vars. *coctei* and *chocoensis* respectively. It is not an easy matter to fix the typical form of *D. tinctorius*; the following remarks will not be superfluous, to justify the course followed by me.

Schneider (Hist. Amph. i. p. 175, 1799) is the author of the name *tinctorius*, but the frog itself was unknown to him. He refers us to Lacepède (Quadr. Ovip. p. 566, pl. xxxix., 1788), who regards the "*Raine à tapirer*" as a variety of *Hyla rubra* Laurenti, and describes it as reddish with two irregular yellowish white longitudinal bands; the figure is hopeless for the purpose



of identification. But as the name "*Raine à tapirer*" is based on an observation recorded by Buffon (Hist. Nat. Oiseaux, vi. p. 235, 1779) to the effect that the frog is used by the savages of Guiana and the Amazon to dye parrots, and is small, azure blue with longitudinal golden yellow bands, and is to be found preserved in the "*Cabinet du Roi*," the best thing to do is to go straight to the description of the first author after Lacepède who had access to the specimens alluded to by Buffon, and this author is Daudin (Hist. Rain. etc., 1802). The larger of the three specimens from Guiana in the Paris Museum, presumably those alluded to by Buffon and Lacepède, is figured in a perfectly recognisable manner on Daudin's pl. viii. fig. 1, and corresponds very nearly with one from Cayenne in the British Museum, which I therefore regard as the typical form of *Dendrobates tinctorius*. Upper parts blackish brown with symmetrical white (yellow) markings forming two bands on the back, meeting on the coccygeal region and extending, above the canthus rostralis, to the end of the snout after expanding on the upper eyelid; a transverse bar connects these bands across the middle of the back, and another branch extends to the shoulder; white markings on the flanks; belly paler brown, with black spots. This is the var. *daudini* Steindachner, Verh. zool.-bot. Ges. Wien, xiv. 1864, p. 262.

VAR. *coctei*.—Hylaplésie de Coctean, Dum. & Bibr. Erp. Gén. pl. xc. fig. 1; *Dendrobates tinctorius*, var. B, Dum. & Bibr. op. cit. viii. p. 654 (1841); *D. tinctorius*, var. *cocteani* Steind. Verh. zool.-bot. Ges. Wien, xiv. 1864, p. 260.

"D'un brun marron ou d'une teinte lie de vin, . . . une tache d'un blanc jaunâtre sur le museau, une autre beaucoup plus grande et de forme ovulaire sur chaque flanc, . . . un large bracelet de la même couleur autour de chaque bras et de chaque jambe. Assez souvent les taches des flancs se confondent sur la région abdominale." Dum. & Bibr. Locality not stated.

Six specimens, all from the Choco, in the British Museum, are referable to this variety:—

a. Tado, Rio San Juan, 230 ft. (M. G. Palmer). Dark reddish brown above, with black spots, black beneath. An oval yellow spot on the top of the head, another occupying the whole flank, widely separated from its fellow on the other side; other large spots are present, one on the forearm, one on the thigh, one on the tibia, and one on the throat.

b. Same locality, same collector. Similar to the preceding, but the spots on the head, throat, and femur absent; the large spot on the flank extends to the shoulder, and those on the forearm and tibia completely encircle the limbs.

c. Upper waters of Condoto River, 1200 ft. (Spurrell). Dark brown above, with bright vermilion-red, sharply defined spots, black beneath. The bright spots are as in *a*, except that the one on the top of the head is situated further back; those on the throat and forearm are absent, but others are present on the left

side of the snout and on the left foot; the forearm is completely encircled by the yellow spot.

*d.* Same locality as *c.* Differs from *c* in the lateral spot being produced as far as the eye on the left side, where it is confluent with the oval spot situated on the upper surface of the head as in *a*; the spot on the tibia surrounds the limb; a yellow spot on the right foot instead of the left.

*e, f.* Same locality as *c* and *d*, and very similar in the markings, which, however, were noted by Dr. Spurrell as of a vivid yellow instead of red. *e* has the lateral spots very large and narrowly separated from each other on the belly, that on the left side extending to the temple; a spot on the right foot; forearm encircled by the red spot. *f* has the spot on the right foot instead of the left.

A further Colombian specimen, from Noanama, S. Juan (M. G. Palmer), is not unlike the preceding, but the spots are smaller and less regular and of a vivid magenta-red. A figure is given to show the disposition of the markings on the black body.

VAR. *chocoensis*. — *Phyllobates chocoensis* Posada Arango, Mémoire sur le poison de Rainette des sauvages du Choco (Paris, 1869); Deyrolle, Rev. et Mag. de Zool. 1872, p. 465, pl. xxvii.

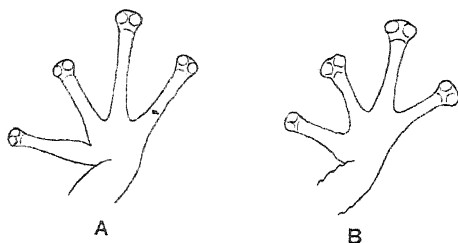
The frog noticed by Posada Arango as furnishing the Choco Indians with a deadly poison for their arrows is described as bright yellow on the head and back and bluish black on the limbs and lower parts. A specimen answering to this description is preserved in the British Museum, from Juntas, Rio San Juan, Choco, 320 ft. (M. G. Palmer).

Nine specimens, obtained by Dr. Spurrell at Peña Lisa, Condoto, 300 feet, may be referred to this form, and show considerable variation in coloration. A snake which started eating one of these frogs was observed to drop it hurriedly. "Ground colour of upper parts a rich orange-yellow, belly dark brown; markings on back and limbs varying from dark reddish orange to chocolate-brown, not sharply defined nor regularly symmetrical; much variation in colour and arrangement of markings; ground colour of upper parts sometimes lemon-yellow or brownish yellow." The specimens which most nearly approach Posada Arango's description have the head and back uniform yellow or with only one dark spot, on the middle of the back, just behind the head; the sides are blackish brown, and the upper surface of the limbs yellow.

The numerous varieties of *Dendrobates tinctorius* are much in want of revision. Among those already described there is one which is unquestionably entitled to specific rank and for which I wish to propose the name *Dendrobates paraensis*. Disks of fingers and toes much larger than in *D. tinctorius*; a small but very distinct tubercle on the inner side of the tarsus, nearer the metatarsal tubercles than the tibio-tarsal articulation. In some

specimens the upper parts, with the exception of fore limbs and feet, are uniform greyish or yellowish white (yellow in life?), the rest of the animal deep black; in others the black predominates, the white being restricted to the upper surface of the head and to

Text-fig. 178.

*Dendrobates tinctorius* (A) and *D. paraensis* (B).

Upper view of hand.

more or less confluent blotches on the back; further specimens are intermediate between the two extremes. From snout to vent 38 mm. Eight specimens, from Para, are preserved in the British Museum, three of which are mentioned in the Catalogue of Batrachians, p. 143 (var. B, *h*, *i*, *k*).

#### 19. *DENDROBATES AUROTENIA*, sp. n. (Pl. CIV. fig. 1.)

Snout truncate, barely as long as the eye; loreal region vertical; interorbital space as broad as the upper eyelid; tympanum not very distinct, three-fifths the diameter of the eye. Fingers slender, first extending beyond second, with rather small disks; toes slender, disks as large as those of the fingers; sub-articular tubercles very feeble; two scarcely prominent metatarsal tubercles and a very feeble fold on the inner side of the tarsus terminating club-shaped half-way between the metatarsal tubercles and the tibio-tarsal articulation. The tarso-metatarsal articulation reaches far beyond the tip of the snout, the tibio-tarsal falling between the eye and the end of the snout; tibia half as long as head and body. Skin smooth, of dorsal region very porous. "Jet-black, with a metallic orange-yellow streak" from the end of the snout along the canthus rostralis and the upper eyelid to the loin; "a few fine gold freckles on thighs and arms."

From snout to vent 30 mm.

A single specimen from Peña Lisa, Condoto, 300 feet.

This frog approaches very closely *D. trivittatus* Spix, differing only in the shorter snout and the absence of tubercles on the back.

## REPTILIA.

## CHELONIA.

## 1. CINOSTERNUM SPURRELLI, sp. n. (Pls. CV. &amp; CVI.)

Jaws strong; beak strongly hooked. Carapace smooth and without keels, flattened on the vertebral region, profile descending very abruptly behind; deep grooves between the shields; posterior border serrated. Plastron smaller than the opening of the shell, not emarginate posteriorly; lobes well movable, front one longer than the fixed portion and slightly shorter than the hind one; gular shield not half the length of the front lobe; suture between the pectoral shields much shorter than that between the humerals; axillary and inguinal shields elongate and in contact with each other. A patch of small horny keeled tubercles on the back of the leg, opposed to one on the thigh. Tail ending in a claw-like scute. Carapace blackish brown, plastron yellow with blackish blotches; head, neck, and limbs blackish above, whitish below; a broad oblique yellowish band on each side of the head, from behind the eye to the neck, passing above the tympanum; jaws yellowish horn-colour.

This very distinct species is represented by a single male specimen, the shell of which measures 115 mm. The curious shape of the first vertebral shield, depicted on Pl. CV., is probably an individual peculiarity and has therefore not been alluded to in the description.

The position of *C. spurrelli* in the system is in group II. A of my Synopsis (Cat. Chelon. p. 38), which group, up to the present, was unrepresented south of Mexico.

## 2. NICORIA NASUTA Blgr.

Described in 1902 from specimens obtained at Bulun and on the Rio Durango, N.W. Ecuador.

The specimen in the present collection is quite young. Shell-length 70 mm. The digits are fully webbed.

## EMYDOSAURIA.

## 3. CAIMAN SCLEROPS Schn.

## LACERTILIA.

## 4. ANOLIS FASCIATUS Blgr.

Only known from Guayaquil and N.W. Ecuador (*A. elegans* Blgr.) "Green above, with darker green markings, yellow on belly; crown of head and neck with faint orange markings. Gular appendage white with six broad orange bands."

## 5. ANOLIS MACULIVENTRIS Blgr.

First described from N.W. Ecuador.

"Gular appendage crimson."

6. *ANOLIS PRINCEPS* Blgr.

This handsome lizard, one of the largest of the genus, was originally described from specimens from N.W. Ecuador. It has since been found in Choco, at Condoto and Tadó, by Mr. M. G. Palmer.

"Yellowish grass-green, brighter about head and neck, with yellow blotches round eyes; diagonal markings brownish black; gular appendage white."

7. *ANOLIS BREVICEPS*, sp. n. (Pl. CVII. fig. 1.)

Head once and two-thirds as long as broad, slightly shorter than the tibia; snout obtuse; forehead and interorbital region concave; frontal ridges short and divergent; upper head-scales very small, keeled; scales of the supraorbital semicircles enlarged, separated by four or five series of scales; enlarged, strongly keeled supraocular scales; occipital as large as or larger than the ear-opening, separated from the supraorbital by three or four series of scales; canthus rostralis sharp, canthal scales three or four; loreal rows seven or eight; seven upper labials to below the centre of the eye; ear-opening moderate, vertically oval. Gular appendage very small in males, barely indicated in females; gular scales keeled. Body not compressed; no dorso-nuchal fold. Dorsal scales very small, keeled, gradually merging into the minute granules of the sides; ventrals larger, roundish-hexagonal, keeled. Limbs slender; the adpressed hind limb reaches the tip of the snout, or between the eye and the tip of the snout; digits feebly dilated; 13 to 15 lamellæ under phalanges II and III of the fourth toe. Tail cylindrical, once and a half to once and two-thirds as long as head and body, without vertebral series of enlarged scales. Male with enlarged postanal scales. Grey-brown to dark brown above, with a ventral series of blackish dots or small V-shaped markings; a dark brown, black-edged cross-band between the eyes and another band from the end of the snout, through the eye, to the side of the neck, very broad and sharply defined on the temple; a more or less distinct whitish streak may be present below this band.

	♂	♀
Total length .....	108	124 mm.
Head .....	12	13
Width of head .....	8	9
Body .....	30	35
Fore limb .....	21	21
Hind limb .....	40	40
Tibia .....	13	13½
Tail .....	66	76

Three specimens.

Near the Central American *A. godmani* Blgr. Distinguished by the shorter head, the smaller gular appendage, and the shorter tail.

8. *ANOLIS NOTOPHOLIS* Blgr.

The gular appendage is red in both sexes.

9. *ANOLIS MACROLEPIS* Blgr.10. *POLYCHRUS GUTTUROSUS* Berthold.

Two specimens, male and female.

Male green above and on the belly, cream-colour on the sides; a vertebral series of cordiform pale reddish-brown black-edged spots pointing forwards, connected by a bright orange vertebral band. Female reddish brown above and beneath, with angular dark brown bands across the back; a few dull green blotches on the head, and on the sacral and anal regions.

11. *CORYTHOPHANES CRISTATUS* Gray.

This remarkable lizard was believed to be restricted to Central America (specimens from British Honduras, Guatemala, Nicaragua, and Costa Rica are preserved in the British Museum), but a specimen from the Rio Tamana, Choco, was in the collection made by Mr. Palmer, and two are in Dr. Spurrell's collection. "Shows rapid changes of colour when alive."

12. *BASILISCUS AMERICANUS* Laur.

Its habitat extends from Panama and Costa Rica to Venezuela and Southern Colombia.

13. *BASILISCUS GALERITUS* A. Dum.

Blackish above, dotted with yellow; upper surface of head and a band on each side of the belly reddish brown; throat white; belly and lower surface of limbs greenish white, speckled with black.

14. *ENYALIOIDES HETEROLEPIS* Bocourt.

Originally described from Veragua. Numerous examples from Colombia and N.W. Ecuador are preserved in the British Museum.

15. *DIPLOGLOSSUS MONOTROPIS* Wiegman.

The largest specimens are very strikingly coloured. Head lemon-yellow with greenish tinge; back chequered brownish black and lemon-green; throat, belly, and sides of body vermillion-red; tail lemon-yellow above, with dark bars, vermillion-red beneath.

16. *AMEIVA BRIDGESII* Cope.

Young black above, with seven whitish longitudinal lines; belly bluish grey; tail blue.

17. *AMEIVA FESTIVA* Licht.

A single, half-grown specimen. Blackish above, with a pale green vertebral band originating on the end of the snout and prolonged on the basal half of the tail; two interrupted white lines along each side of the body.

A specimen from Medellin, Andes of Colombia (Coll. A. E. Pratt), is in the British Museum.

18. *ANADIA VITTATA*, sp. n. (Pl. CVII. fig. 2.)

Head depressed, with long, acutely pointed snout; body much elongated. Nostril in the suture between two nasals. Fronto-nasal pentagonal, a little longer than broad, longer than the prefrontals, which form a long suture; frontal octagonal, narrow behind, in contact with three supraoculars; two large parietals on each side, both in contact with the interparietal, which is not twice as long as broad and followed by three subequal occipitals; four supraoculars, first smallest, second and third equal; four or five supraciliaries; a loreal, a freno-orbital, and a row of infraorbitals; temples with rather small shields; seven upper labials, first narrowly in contact with the fronto-nasal; six lower labials; chin-shields, one anterior and four pairs, three pairs forming a median suture; gular scales subequal, squarish, juxtaposed; collar-scales nine, feebly enlarged. Scales on body forming regular whorls, the dorsals quadrangular-subhexagonal, as long as broad, the laterals a little narrower, the ventrals quadrangular, those of the two median rows larger; 30 scales round the middle of the body, 58 from occiput to sacrum inclusively. Præanal plates in three rows, posterior median pair largest. Two præanal and one femoral pore on each side. Limbs and tail as in *A. ocellata*. Pale brownish white above, with three dark brown longitudinal stripes, the vertebral edged with black and breaking up into three black lines behind the nape; lower parts white; tail with three serrated or zigzag brown bands.

Total length (tail injured) .....	112 mm.
Head .....	10
Width of head .....	5
From end of snout to fore limb .....	15
" " " " " vent .....	40
Fore limb .....	10
Hind limb .....	12

A single specimen.

This species is closely allied to *A. ocellata* Gray.

19. *ALOPOGLOSSUS COPII* Blgr.

Originally described from Eastern Ecuador, this species has since been found in Western Ecuador, but had not been reported from Colombia.

20. *AMPHISBENA FULIGINOSA* L.

Received alive by the Zoological Society.

## OPHIDIA.

21. *TRACHYBOA BOULENGERI* Peracca.

A single young specimen of this species, recently described by Peracca, Ann. Mus. Zool. Univ. Nap. iii. 1910, No. 12, was referred by me to *T. gularis* Peters, P. Z. S. 1898, p. 109, pointing out the characters in which it differed from Peters's description and Jan's figure. The spine-like raised scales on the snout and above the eyes, which are so striking in larger specimens, are merely indicated in this specimen.

The British Museum possesses two adult specimens from N.W. Ecuador, and two from the Choco are now added by Dr. Spurrell. I append particulars of these four specimens:—

1. ♀, St. Javier, N.W. Ecuador. Total length 430 mm.; tail 40. Sc. 27; V. 139; C. 24. Sixth labial entering the eye on the right side.
2. ♂, with claw-like anal spurs. Same locality. Total length 265 mm.; tail 30. Sc. 30; V. 133; C. 28. Fifth labial entering the eye.
3. ♂, with claw-like anal spurs. Peña Lisa, Choco. Total length 230 mm.; tail 27. Sc. 30; V. 131; C. 23. Labials all excluded from the eye.
4. ♀, same locality. Total length 270 mm.; tail 25. Sc. 33; V. 137; C. 20. Labials all excluded from the eye.

The type specimen described by Peracca, the habitat of which is unknown, has only 23 scales round the thickest part of the body. The number of scales in *Trachyboa* is probably as variable as it is in *Atheris*.

22. *STREPTOPHORUS ATRATUS* Hallow.

A specimen taken from the stomach of an *Elaps rosenbergii*, after having swallowed a *Cacilia intermedia*.

23. *DRYMOBIUS DENDROPHIS* Schleg.24. *PHRYNONAX FASCIATUS* Peters.25. *HERPETODRYAS CARINATUS* L.26. *LEPTOPHIS BILINEATUS* Gthr.

One of the three specimens is bright green above, as in the type, the two others are of a metallic bronze on the back and sides, the head dark green, the sides of the neck green, the lower parts pale green.

The habitat of this species extends from the Isthmus of Tehuantepec to N.W. Ecuador.



27. *LEPTOPHIS OCCIDENTALIS* Gthr.

28. *LIOPHIS ALBIVENTRIS* Jan.

29. *ATRACTUS MULTICINCTUS* Jan.

In its coloration in the fresh condition (occipital blotch bright red) this harmless snake is not without resemblance to *Elaps meparititus*.

30. *ATRACTUS IRIDESCENS* Peracca.

This species was described (Boll. Mus. Torin. xi. 1896, No. 252) from a single specimen, origin unknown. Three specimens in Dr. Spurrell's collection may, I think, be referred to it.

a. ♀. 255 mm.; tail 36. V. 144; C. 37.

b. ♀. 215 mm.; tail 32. V. 134; C. 32.

c. Yg. 102 mm.; tail 11. V. 143; C. 26.

The iridescence from which the species derives its name is strongly marked in these specimens. Dark brown above, with two dorsal series of transverse blackish spots, which may alternate or form cross-bars, and may be bordered by yellow dots or short streaks; in specimen *a* the belly is white spotted with black in front, uniform black behind; in specimen *b* it is white with a median series of black spots and a series of smaller spots on each side.

31. *PETALOGNATHUS NEBULATA* L.

32. *HIMANTODES CENCHOA* L.

33. *LEPTODIRA ALBOFUSCA* Lacep.

34. *OXYRHOPUS CLOELIA* Daud.

A specimen two metres long.

35. *HOMALOCRANIUM MELANOCEPHALUM* L.

36. *HOMALOCRANIUM CORALLIVENTRE*, sp. n. (Pl. CVIII. fig. 1.)

Eye about half as long as the snout. Rostral a little broader than deep, the portion visible from above about half as long as its distance from the frontal; internasals about two thirds the length of the præfrontals; frontal hexagonal, obtuse-angled in front, acute-angled behind, nearly once and a half as long as broad, longer than its distance from the end of the snout, shorter than the parietals; nostril between two nasals, the posterior of which is in contact with the præocular; two postoculars; temporals 1 + 1; seven upper labials, third and fourth entering the eye, seventh largest; four lower labials in contact with the anterior chin-shields, which are a little shorter or a little longer than the

posterior and in contact with the symphysial. Scales in 15 rows. Ventrals 135-141; anal divided; subcaudals 56-59. Dark brown above, scales edged with black: a large yellowish spot on the upper lip behind the eye, and a yellowish occipital bar encroaching on the posterior part of the parietal shields; gular region white, rest of lower surfaces bright coral-red.

Total length 275 mm.

Two specimens, male (V. 135; C. 59) and female (V. 141; C. 56).

Very closely allied to *H. alticola* Blgr., from Santa Rita, north of Medellin, Colombia (9000 feet), but eye larger and frontal a little longer in proportion to its width.

37. *STENORHINA DEGENHARDTI* Berthold.

38. *ELAPS CORALLINUS* L.

39. *ELAPS ROSENBERGII* Blgr.

I have examined several specimens from various localities in N.W. Ecuador, and also one obtained by Mr. M. G. Palmer at Tado, Choco.

40. *ELAPS MICRIPS*, sp. n. (Pl. CVIII. fig. 2.)

Eye extremely minute, barely one-fourth as long as its distance from the mouth. Rostral broader than deep; frontal a little broader than the supraocular, once and one-third as long as broad, as long as the præfrontals, half as long as the parietals, which are longer than their distance from the internasals; one pre- and two postoculars; temporals 1+1; seven upper labials, third much longer than fourth, third and fourth entering the eye, the latter very narrowly; four lower labials in contact with the anterior chin-shields, which are as long as the posterior. Scales in 15 rows. Ventrals 205; anal divided; subcaudals 20. Tail ending obtusely. Black above, with 46 narrow white, black-spotted cross-bars; these widen on the belly, which is barred black and white; an orange band across the head, from between the eyes to near the end of the parietal shields; tail orange-red, with a black ring and a black terminal spot surrounding a small white spot.

Total length 650 mm.; tail 25.

A single female specimen.

This new *Elaps* resembles strikingly *E. mipartitus* D. & B. in the coloration, but is well distinguished by the much smaller eye and by the proportions of the head-shields.

41. *LEPTOGNATHUS SPURRELLI*, sp. n. (Pl. CVIII. fig. 3.)

Body very slender, strongly compressed. Eye large. Rostral small, about once and a half as broad as deep, not visible from above; internasals one-third the length of the præfrontals;

frontal as long as broad, nearly as long as its distance from the end of the snout, much shorter than the parietals; nasal divided; loreal once and a half as long as deep, bordering the eye; no preocular; prefrontal entering the eye; two postoculars, lower very narrow; temporals 3 + 3; eight upper labials, fourth and fifth entering the eye; four pairs of chin-shields, the anterior very small and in contact with the symphysial, the second larger and a little longer than broad. Scales in 15 rows, vertebrals strongly enlarged, nearly as long as broad. Ventrals 208; anal entire; subcaudals 132. Reddish brown above, with very large blackish-brown blotches separated on the back by narrow interspaces of the ground colour, these interspaces gradually widening down the sides, where the blackish blotches are edged by small white spots: these blotches form nearly complete rings on the anterior part of the body, whilst further back they are gradually more widely interrupted by the yellowish-white colour of the belly; lower surface of tail brown, with a few small whitish spots; head uniform reddish brown above; lips white, with small black spots. "Iris golden."

Total length 680 mm.; tail 235.

A single male specimen.

Closely allied to *L. annulata* Gthr., from Costa Rica, and *L. temporalis* Werner, from Ecuador.

#### 42. LACHESIS MUTUS L.

This is the *Bothrops acrochordus* of Garcia\*. Grows to 2½ metres.

#### 43. LACHESIS ATROX L.

#### 44. LACHESIS MONTICELLII Peracca.

This Pit-Viper, easily distinguished from *L. lanceolatus* by the shape of the rostral shield, which is much deeper than broad, was described along with *Trachyboa boulengeri* from a specimen of unknown origin. It is interesting to find the two snakes associated in this collection.

Two female specimens:—

a. 920 mm.; tail 160. Sc. 29; V. 210; C. 86.

b. 570 mm.; „ 100. „ 27; „ 212; „ 87.

*Lachesis punctatus* Garcia, l.c. p. 31, pl. —, perhaps represents the same species.

#### 45. LACHESIS BRACHYSTOMA Cope.

The range of this species is now known to extend from the Isthmus of Tehuantepec to N.W. Ecuador.

Described and figured by Garcia as *Thanatophis sutus*.

\* Los Ofidios venenosos del Cauca (Cali, 1896), p. 23, pl. —.

## EXPLANATION OF THE PLATES.

## PLATE CII.

- Fig. 1. *Bombophrynus*, p. 1022, enlarged, and outline natural size.  
 2. *Agalyptis calcarifer*, p. 1023.  
 2a. " " Side view.  
 2b. " " Open mouth.

## PLATE CIII.

*Agalyptis spurrelli*, p. 1024. Female and eggs.

## PLATE CIV.

- Fig. 1. *Desmognathus aureofemina*, p. 1029.  
 2-4. " *tinctorius*, var. *coctei*, p. 1027.  
 5-6. " " var. *chocoensis*, p. 1028.

## PLATE CV.

*Cinosternum spurrelli*, p. 1030. Upper view.

## PLATE CVI.

*Cinosternum spurrelli*, p. 1030. Lower view.

## PLATE CVII.

- Fig. 1. *Anolis breviceps*, p. 1031.  
 1a. " " Side view of head.  
 1b. " " Upper view of head, enlarged.  
 2. *Anadia vittata*, p. 1033.  
 2a. " " Upper view of head, enlarged.  
 2b. " " Side view of head,  
 2c. " " Ventral and anal region, enlarged.  
 2d. " " Lower view of head, "

## PLATE CVIII.

- Fig. 1. *Homalocranium corallirentre*, p. 1035.  
 1a. " " Upper view of head, enlarged.  
 1b. " " Side view of head, "  
 2. *Elaps microps*, p. 1036.  
 2a. " " Upper view of head, enlarged.  
 2b. " " Side view of head, "  
 3. *Leptognathus spurrelli*, p. 1036.  
 3a. " " Upper view of head, enlarged.  
 3b. " " Side view of head, "  
 3c. " " Lower view of head, "

60. The Peroneal Muscles in Birds. By P. CHALMERS MITCHELL, M.A., D.Sc., LL.D., F.R.S., F.Z.S., Secretary to the Society.

[Received October 28, 1913: Read November 25, 1913.]

(Text-figures 179-190.)

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In the dissection of an example of *Baleniceps rex*, which formed the basis of a recent contribution to the Society's Proceedings (*supra*, pp. 644-703), I was interested to notice that one of the very few characters in muscular anatomy which the Shoe-bill shared with Herons, to the exclusion of Storks, was the presence of the leg muscle known as the *Peroneus brevis* or *profundus*. On looking up the literature relating to the peroneal muscles in birds, I found that even Dr. Gadow's careful description of these muscles (Gadow in Bronn's 'Thier-Reich,' Aves, pp. 180-182) was based on a relatively small number of individuals and types, and that his work, together with the insignificant contributions of earlier and later writers, supplied only a vague and dubious picture of the anatomical facts in Aves. I wished to make a survey of these muscles as nearly as possible complete. Accordingly I have dissected them in the birds that have died in the Society's Collection for some months, have made use of the rich spirit material stored in the Prosectorium (most of it dating from the time of Garrod and Forbes), and have been allowed to examine some specimens in the stores of the British Museum (Natural History) and of the Museum of the Royal College of Surgeons, and Dr. Gadow has also obliged me with material from Cambridge. My observations therefore relate to several hundred birds, distributed, as will be seen later, fairly well over the whole Avian system. Theoretically, no doubt, it is necessary to work out the complete anatomical structure of an animal if one would understand any portion of it, but in practice this is impossible, and in my opinion the examination of a single structure or even portion of a structure through the whole series by a single observer cannot fail to be interesting and instructive. The method, moreover,

has the practical advantage that the anatomist gains, at least temporarily, a useful dexterity in exposing the structures on which he is engaged and is able to cover much ground in a relatively short space of time.

After giving an account of the muscles in a generalized type, I shall proceed to a systematic description of the conditions presented, following the classification given by Dr. Gadow in the article *BIRD*, in the Eleventh Edition of the *Encyclopædia Britannica*, and finally shall discuss some of the problems suggested by the degree of coincidence between the varying conditions of these muscles and a classification which is based on other anatomical facts.

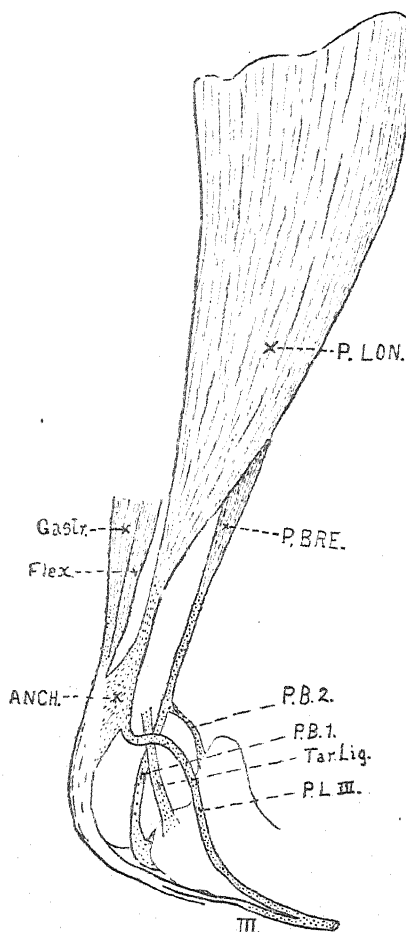
*The Peroneal Muscles in CHALCNA CHAFARIA (text-fig. 179).*

In some respects the Screamers are generalized birds with affinities pointing in many directions, and it happens that the condition of the peroneal muscles in other birds can be easily described as specializations of the Screamer condition chiefly by loss of parts.

*Peroneus superficialis seu longus.*—This is the most superficial mass of muscle seen when the skin is removed on the outer, upper aspect of the leg from the knee downwards. Its very large fleshy mass arises from the anterior and lateral crista of the tibia, from the head of the fibula and partly from the fascia covering the knee. Laterally, where it is bounded by the external head of the gastrocnemius on the one side, and the tibialis anticus on the other, its fasciæ are closely attached to the fasciæ of these muscles. The muscular mass is roughly triangular, and from the broad base at its origin from the upper end of the tibia and fibula, it converges to a flat tendon which is apparent about three quarters way down the leg and rather more on the outer than the anterior aspect. There is a deep origin formed by a comb of fibres projecting inwardly as a keel along nearly the whole length of the triangular portion of the muscle and arising partly from the whole length of the fibula and partly from the tibial surface immediately under the fibula. When the tendon has nearly reached the tarsal joint, it gives off a very broad and strong anchor (text-fig. 179, *Anchor*) to the cartilaginous sustentaculum which is pierced by some of the flexor tendons and joined superficially by the gastrocnemius tendon. It is then continued outwards and downwards across the ankle-joint, immediately under the skin, but running through a synovial membrane which has to be cut open to expose it fully, and ultimately, about a quarter of the distance down the tarso-metatarsal shaft, it fuses with the flexor tendon of the third digit (*flexor primus seu perforatus III*) (text-fig. 179, P.L. III). It is supplied by a branch of the ischiadic nerve.

The function of this muscle is to straighten the tarsus metatarsus on the tibio-tarsus and then to flex the third toe. When

Text-fig. 179.

Peroneal muscles in *Chauna chavaria*.

Right leg, external aspect. Muscle striped: tendon dotted.

P.LON. Peroneus longus. ANCH. "Anchor": attachment of P. longus tendon to Sustentaculum of Flexor tendons. P.L. III. Slip of P. longus tendon passing across the ankle-joint to fuse with III, tendon of Flexor perforatus of the third toe.

P.BRE. Peroneus brevis. P.B. 1. Tendon of insertion of P. brevis passing across the tarsal joint to insertion to proximal end of the tarsus-metatarsus. P.B. 2. Slip of Peroneus brevis tendon, not usually present in birds.

Tar. Lig. Ligament crossing the tarsal joint, deep of P.L. III and superficial to P.B. 1.

Gastr. External head of gastrocnemius muscle.

Flex. Flexor tendons.

the tendon has been dissected out of its synovial groove, it appears too long for its purpose, but if its action be tested before this dissection has been made, it is clear that the straightening of the foot is carried out by the action on the sustentaculum and that subsequently the third toe is bent by the special slip.

The arrangement is odd and very striking, and it is extremely difficult to believe that it has been independently developed in the large number of different groups of birds in which it occurs. In my opinion the disposition of the muscle and its tendons shown in *Chauna* can be explained best if it be regarded as the specialized derivative of a condition in which the perforated flexor muscles and their tendons were continuous with each other and with the peroneus; as the foot and its digits became specialized, the fasciæ of insertion became strengthened along the lines leading to each digit, and finally by the disappearance of the connecting fasciæ the continuous sheet became broken up into separate tendons; as the tibio-tarsus became longer the peroneal slip to the tendon of digit III assumed its odd course. All the stages in the possible differentiation of continuous fasciæ into highly specialized tendons still exist in the case of the alar tendons of birds. The differentiation of the foot, however, must have taken place before the groups of birds became separated, and, as I shall show later, the various conditions of the peroneus in the different groups of birds can all be explained as differentiations of the condition in *Chauna*, in particular by the loss of some part.

*Peroneus profundus* seu *brevis* (Tibialis posticus of R. W. Shelfeldt, "Myology of the Raven," 1870, p. 228).—This is a much simpler and more slender muscle arising fleshy from the fibula and the adjacent surface of the tibia on their anterior aspects, beginning about the level of the insertion of the biceps tendon and extending a little beyond the distal extremity of the fibula, where it passes into a stout rounded tendon (text-fig. 179, P.BRE). The greater portion of the muscle is concealed by the edges of the tibialis anticus and of the superficial peroneal which meet above it. The tendon as it approaches the end of the tibio-tarsus is very close to the bone and is deep of the peroneus longus tendons; it flattens out, runs through a synovial channel, crosses the tarsal joint overlain by a ligament (text-fig. 179, Tar. lig.), which also crosses the joint, and is inserted to the proximal edge of the tibio-tarsus on its posterior, outer aspect (text-fig. 179, P.B.1). In *Chauna* it also has a second attachment to the antero-median end of the tarsal shaft (text-fig. 179, P.B.2).

This muscle flexes the tarsus-metatarsus on the tibio-tarsus, and at the same time slightly rotates the foot, depressing the axial, or great toe side, and raising the abaxial, or fourth toe side. The latter action varies with the exact position of the insertion and is often very feeble, as, indeed, is the action of the muscle as a whole.



## SYSTEMATIC DESCRIPTION.

I have found that the following points are the most notable:—

*Peroneus longus*.—Origin: “superficial,” *i. e.* forming a fairly broad external sheet at the proximal end of the tibio-tarsal shaft and arising chiefly from the head of the tibia and fibula and from the fasciæ over the knee-joint; “fascial,” from the fasciæ of the tibialis anticus on the one side and from that of the external gastrocnemius and the underlying flexors on the other; “deep,” from the side of the fibular shaft and the adjacent area of the tibia on the opposite side from the origin of the *peroneus brevis*. The “fascial” origin is the least important morphologically and is correlated with the strength and width of the muscle. “Anchor,” to the cartilaginous sustentaculum through which the flexor tendons run at the tarsal joint. “Slip to III,” the superficial tendon which runs from the *peroneus* over the tarsal joint to join the perforated flexor tendon of the third toe.

*Peroneus profundus*.—Origin. Presence or absence of a bony or fibrous bridge at the lower end of the tibio-tarsus. Tendon of insertion.

Relative size of the two muscles.

## RATITÆ.

*Struthionæ*. *Struthio*.—The *peroneus longus* is enormous. Superficial origin extends over to the femoro-fibular ligament and the patella. Fascial origin present. Deep origin represented by a separate head from the lower end of the fibula. Anchor is broad and flat but short. Slip to III strong and rounded. *Peroneus brevis* absent, but there is a short stout ligament which may represent either the lower portion of the muscle, or, in my opinion, more probably the ligament which crosses the tarsal joint in *Chauna*.

*Rheæ*. *Rhea americana* (two examples).—*P. longus* as in *Struthio*, except that the deep origin extends for the greater part of the length of the fibula. *P. brevis* absent, but tarsal ligament present.

*Casuarii*. *Casuarus uniappendiculatus*.—*P. longus* enormous; superficial and fascial origins very extensive, deep origin as in *Rhea*. Anchor short, very wide and partly in slips. Slip to III stout. *P. brevis* absent but there is a stout tarsal ligament.

*Dromæus novæ-hollandiæ*.—As in *Casuarus*, but *P. longus* not quite so large.

*Apterygæ*. *Apteryx* (? species) (three examples).—*P. longus* very large; superficial and fascial origins good, but deep origin very slight. Anchor broad and short; slip to III a rounded tendon. *P. brevis* very much reduced but present as a small flat tendon arising from a few muscular fibres and running in the normal position under the slip to III. This is notably different from the tarsal ligament in the other “struthious birds” and is quite certainly a rudiment of the *Peroneus brevis*.

In the Ratites the *P. longus* is the dominant muscle and does not differ except in minor details from the type in *Chauna* which, for convenience, I may call the "normal" arrangement. The *Peroneus brevis* is at least functionally absent, but the *Apteryges* stand apart from the others in possessing an undoubted vestige of it.

## CARINATÆ.

### COLYMBOMORPHÆ.

#### COLYMBIFORMES.

*Colymbi.* I have not examined a Diver.

*Podicipedes.* *Podiceps cristata* and *P. minor*.—In both these Grebes the *P. longus* was badly developed, with delicate superficial and deep origins passing into a long rounded tendon about half-way between the knee and the tarsal joint. In the Crested Grebe this tendon passed straight to the sustentaculum, so that its insertion was represented only by a narrow anchor, there being no slip to III. In the Little Grebe the anchor was similar but I was able to trace a minute but normal slip to III. On the other hand, in the Crested Grebe there was a minute and certainly functionless tendon representing the *P. brevis* which I did not find in the Little Grebe.

#### SPHENISCIFORMES.

*Sphenisci.* *Spheniscus demersus*.—*P. longus* rather weak but all origins present; anchor and slip to III both slender and short. *P. brevis* was also slender but arose fleshy from the greater length of the shaft of the fibula and tibia and was inserted by the usual slender flat tendon running in a synovial groove under the slip to III. Gadow mentions that it is present but weak in *Aptenodytes*. Beddard's statement that it does not occur in Penguins is erroneous.

#### PROCELLARIIFORMES.

*Tubinares.*—*Daption capensis*. *Procellaria* (? species). *Oceanodroma* (? species).—In the Cape Pigeon and the two Petrels the *P. longus* was rather small with only the superficial origin, which quickly passed into a very long, slender tendon ending in a delicate anchor and a slender slip to III. The *P. brevis* had a short but strong origin from high up the fibula; this passed into a strong and very long tendon with the usual flat insertion. The *P. brevis* is rather stronger than the *P. longus*. The examples of Petrels which I examined were part of the material of W. A. Forbes and had been preserved in spirit for at least thirty years. I was interested to note that they still retained a very strong musky odour, so clinging that although I used several kinds of soap and petrol I could not get rid of it for several days.

It is clear that the Colymbomorphae present no coherent picture, the Petrels being sharply marked off from the others by the relative dominance of the *P. brevis*.

#### PELAGOMORPHÆ.

##### CICONIIFORMES.

##### Steganopodes.

Phaethontidae. *Phaethon*.—*P. longus* normal but rather small, with superficial and deep origin, broad anchor and slip to III. *P. brevis* normal, with long muscular origin and short tendon with usual flattened insertion.

Sulidae. *Sula bassana*.—*P. longus* normal and large but with only superficial and slight fascial origin. Broad short anchor and slip to III. *P. brevis* absent.

Phalacrocoracidae. *Phalacrocorax* (?species).—*P. longus* normal and large; origin, anchor and slip to III as in *Sula*. *P. brevis* strong but very short, arising only from the lower end of the tibial shaft, distal to the fibula, and with normal insertion by flattened tendon.

Fregatidae. *Fregata*.—*Peroneus longus* large and strong but origin practically only deep from the whole length of fibula and adjacent surface of tibia on side turned from the *brevis*. Broad anchor and good slip to III. *P. brevis* minute but quite distinct and normal, with long slender belly and tendon passing under a fibrous bridge and then flattening out to pass to usual insertion.

Pelecanidae. *Pelecanus*.—I have not had a recent opportunity of examining a Pelican, but from my old notes I find that the *P. longus* is large and normal with the usual anchor and slip to III, and that the *P. brevis* is present but minute.

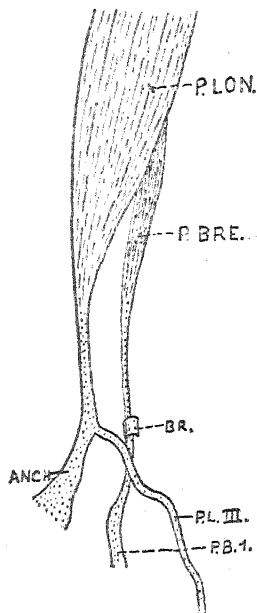
Ardeae (from these I exclude *Scopus* and *Baleniceps*). *Ardea egretta*, *A. herodias*, *A. herodias lessoni*, *A. purpurea*. *Ardetta minuta*. *Nycticorax gardeni*, *N. violaceus* (2 examples). *Botaurus stellaris*, *Cancroma zelodoni*.—In all these the *P. longus* is fairly large (text-fig. 180), but has only the superficial origin with slight fascial origin. The anchor is rather long, broadens out, and at least in one case (*A. herodias lessoni*) was in two slips. The *P. brevis* is well developed usually from about three-quarters the length of the shaft but chiefly from the fibula. The long tendon passes through a fibrous bridge and then flattens out to the normal insertion. I think there must be some mistake in Gadow's statement that the *P. brevis* is absent in *Ardea*. I find that its presence is one of the differences between Herons and Storks. In *Ardetta minuta* and *Cancroma* it is particularly strong.

Scopidae. *Scopus umbretta*.—The *P. longus* is large with superficial and slight fascial origin, broad anchor and good slip to III. The *P. brevis* is either actually absent or represented by a very small ligament.

Balenicipitidae. *Baleniceps rex*.—*P. longus* a strong broad

muscle with only superficial and fascial origins. Anchor broad and good slip to III. The P. brevis is strong but short, arising only from the tibia distal to the end of the fibula; its flattened tendon passes over to the usual insertion.

Text-fig. 180.

Peroneal muscles in *Nycticorax gardeni*.

Description and lettering as in Text-figure 179 (p. 1041).

Br. Bridge traversed by the tendon of the P. brevis.

Ciconiæ. *Ciconia nigra*. *Dissura episcopus*. *Leptoptilus crumeniferus* (2 examples). *Mycteria americana*. *Pseudotantalus ibis* and *Tantalus loculator*.—In all these Storks the conditions were practically identical. The P. longus was large and strong with superficial and fascial origins and no deep origin, very broad anchor and good slip to III. The P. brevis was absent, but running across the tarsal joint parallel with the slip to III, and therefore approximately at right angles with the normal position of the P. brevis tendon, was a stout elastic ligament which kept the tarsal joint flexed, so that after death the joint could not be straightened without force until this had been cut. At first I thought that this ligament might represent the brevis, but its direction is different, and it does not resemble the indubitable vestiges of the brevis which occur in some other birds.

Ibididae. *Carphibis spinicollis*. *Platalea leucorodia*. *Plegadis falcinellus*.—In these the P. longus is normal with superficial and fascial origins, only a few fibres of deep origin, good broad anchor and slip to III. The P. brevis is present but very weak, arising by a few thin fibres from the greater part of the length of the fibula and passing into a slender but long tendon with the usual flat insertion.

Phenicopter. *Phenicopterus antiquorum*.—In the Flamingo the P. longus is strong with only the superficial and fascial origins, with good wide anchor and slip to III. The P. brevis is absent.

The general picture presented by the Ciconiiformes is of a large well formed longus muscle chiefly with superficial origin, and a brevis muscle almost invariably slender and showing a strong tendency to disappear, but none the less with the presence or absence following the minor divisions of the assemblage, and not being sporadic in the genera.

#### ANSERIFORMES.

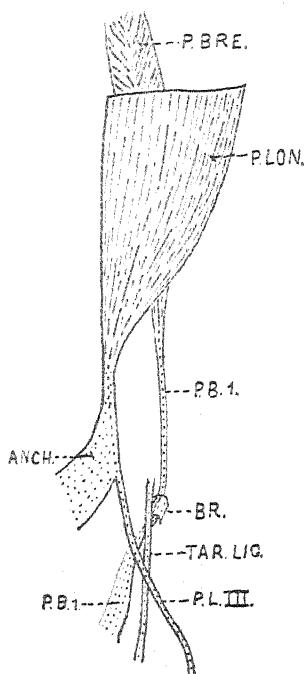
Palamedea. *Chauna chararia*. *Palamedea cornuta*.—I have already described the conditions in these (*supra*, p. 1040).

Anseres. *Cygnus olor*, *C. nigricollis*. *Ex gallericulata* and *Ex sponsa*. *Cereopsis nova-hollandiae*. *Chloëphaga inornata*. *Dendrocygna fulva*. *Querquedula castanea*. *Metopiana peposaca*. *Edemia nigra*. *Mergus serrator*.—In the Swans, Geese and Ducks the P. longus is large with a very broad superficial origin wrapped round the front of the knee, partly covering and partly with fascial origin from the tibialis anticus and a lesser extension towards the gastrocnemius. The muscle narrows rapidly (text-fig. 181) to a rounded tendon from which a very broad anchor, frequently in separate slips, is given off; the main tendon forming the slip to III. The P. brevis is always present and usually large, with a central tendon and pinnate slips of fibres from the greater part of the fibula and adjacent surface of the tibia. It frequently dips under a fibrous bridge and then flattens out and has an unusually wide insertion to the abaxial side of the end of the tibio-tarsus. There is usually one, and not infrequently a second separate tendon running across the tarsal joint. The variations within the group are small, all the normal parts being present. The deep origin of the longus is usually very slight, but as an exception it is well-marked in *Dendrocygna*. The anchor is very broad and short, and usually in separate slips, but in the ducks generally and in *Dendrocygna* it is rather more fan-shaped. In *Edemia* the brevis is very short, arising only from the tibia below the fibula and from a small portion of the fibula; its tendon, moreover, instead of crossing under the slip to III runs parallel with it, and is inserted to the axial edge of the tarsus-metatarsus.

In the Anseriformes the peroneals are both well developed,

the longus, however, being relatively the larger, but the brevis is actively functional and in addition to its flexion of the tarsal joint has a notable rotating action.

Text-fig. 181.

Peroneal muscles in *Aëx sponsa*.

Description and lettering as in Text-figure 179.

The Per. longus has had the proximal portion removed to show the P. brevis.

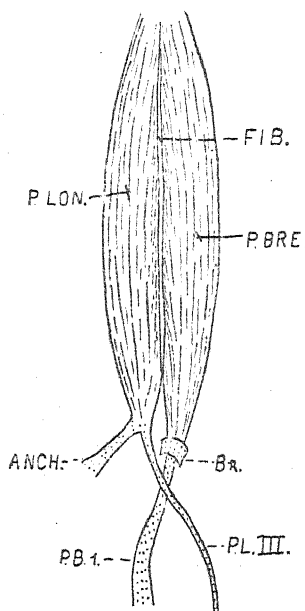
#### FALCONIFORMES.

*Cathartæ*. *Cathartes aura* (2 examples).—The P. longus is a strong muscle, with good but rather narrow superficial origin, with fascial origin chiefly on the side of the tibialis anticus, and with extensive deep origin. The anchor is broad and short and the slip to III is very strong. The P. brevis is very slender, arising only from the distal two-thirds of the fibula, then passing into a rounded tendon much weaker than the slip to III under which it runs, and then flattens out to the normal insertion. The dominance of the longus over the brevis recalls the condition in the *Ciconiiformes* and differs from that present in *Accipitrine* birds (excluding *Serpentarius*).

Accipitres. Serpentariidæ.—I have had no recent opportunity of examining a Secretary bird, but I infer from Dr. Gadow's statement ("Aves" in Thier-Reich) that both peroneals are present, and that as *P. longus* is very large the condition is generalized and thus like what exists among the Ciconiiformes.

Vulturidæ and Falconidæ. *Gypætus barbatus*. *Tinnunculus alaudarius*. *Falco peregrinus* (2 examples). *Aquila verreauxi*. *Haliaetus leucogaster*. *Ictinia mississippiensis*. *Circus gouldi*.—In all these birds both peroneals are present, but the *P. brevis* is the more powerful and the *P. longus* tends to be reduced only to its deep origin. In the Lämmergeier there is the greatest resemblance with the normal arrangement. The *P. longus* has all

Text-fig. 182.

Peroneal muscles of *Falco peregrinus*.

Description and lettering as in Text-figure 179.

Fib. Anterior edge of fibula.

three origins, but the superficial origin is rather narrow and partly reduced. In all the others the superficial and fascial origins have practically disappeared, so that the muscle, as shown in the case of the Falcon (text-fig. 182), almost exactly balances the *P. brevis*, arising from the other side of the fibula and the adjacent area of the tibia along the greater part of the length of

the shaft. The anchor is always present and is usually rather long and slightly fan-shaped. The slip to III is always present and normal. The *P. brevis* is very strong; it arises in the Lämmergeier only from the lower end of the fibula and the tibia distal of this; in *Ictinia* its origin begins higher up; in the others, as shown in text-fig. 182, it arises from nearly the whole length of the fibula below the biceps insertion, from the adjacent surface of the tibia and from the tibia distad of the end of the fibula. Its very strong tendon passes under a fibrous bridge which may be calcified in old birds, then flattens out and passes in the usual synovial sheath under the slip to III to its normal insertion.

It is plain that in these birds-of-prey the superficial origin of the *P. longus* has been partly or completely lost and that the *P. brevis* has greatly increased in relative importance, until it may surpass the *P. longus*.

*Pandionidae. Pandion haliaëtus*.—In the Osprey I found no trace of the *P. longus*, in which I am confirmed by Dr. Gadow. The *P. brevis* was short and not very strong, arising from the usual origin limited to the lower half of the shaft and passing into a weak tendon, which after traversing a bony bridge, flattened out and had the normal insertion of this muscle. As ornithologists, arguing from other features, have differed as to placing the Osprey with the Eagles and Vultures, or with the Owls, it is of some interest to note that in the Owls also only the *P. brevis* is present.

Apart from *Pandion*, it is clear that the Falconiformes generally show a gradual reduction or specialization of the *P. longus*, always retaining, however, the deep origin, the anchor and a strong normal slip to III, and a gradual increase in size of the *P. brevis*.

Gadow unites the Ciconiiformes, Anseriformes, and Falconiformes into the "Legion" Pelargomorphæ. Again excepting *Pandion*, it appears that throughout the Legion, the *P. longus* remains a large and important muscle always with a good anchor and good slip to III, but that the *P. brevis* offers every condition from that of perfect equality with or even superiority to the *longus* in the specialized Falcons, to complete absence.

#### ALCECTOROMORPHÆ.

##### TINAMIFORMES.

*Crypturi. Rhynchotus rufescens* (4 examples). *Nothura maculosa. Calodromas elegans* (3 examples).—In all the Tinamou I examined, the *P. longus* was well developed, with very large superficial and fascial origins and long deep origin. The anchor was strong and broad and the slip to III strong. I noticed that in a Rufous Tinamou the *P. longus* first straightened the tarsal joint and then flexed sharply the second as well as the third digit. On dissecting out the tendons, I found that the tendon of the perforated



flexor muscle of the third digit, after being joined by the tendon from the peroneus, gave off not only the slip to the perforated and perforating flexor of digit III which occurs in birds belonging to many different groups, but also a slip to the perforated flexor tendon of digit II, an arrangement which I have not noted or found recorded in any other bird.

The *P. brevis* was present in all the *Tinamus* I examined; in *Rhynchotus* it was very feeble and slender, arising from the greater part of the length of the fibula and passing into a thin tendon which flattened out, and passing under the slip to III had the normal insertion. In *Nothura* its origin was from the lower part of the fibula, and in *Calodromas* it was extremely minute and reduced to a few fibres and a tendon just visible, but running the usual course. The definite presence of the *P. brevis* in *Tinamus* is in contrast with its equally definite absence in most of the Struthious birds, but resembles the condition in *Apteryx*.

#### GALLIFORMES.

Mesitidæ.—I have had no opportunity of examining *Mesites*, and Milne-Edwards does not refer to the peroneal muscles. It would be interesting to know their disposition, as in *Eurypyga* the tendon is characteristically long, and very different from the arrangement in Galliform birds.

Turnices. *Turnix dussumieri*.—The *P. longus* is present and rather strong, with the three origins, a good anchor and slip to III. The *P. brevis* is slender but arises from nearly three-quarters of the shaft, from the fibula and tibia, and passes into a short tendon which flattens out to the normal insertion.

#### Galli.

Megapodiidæ. *Talegalla lathamii*.—The *P. longus* is very strong with large superficial and good fascial origins but no deep origin. Anchor strong but narrow, and good slip to III. The *P. brevis* is also good, from the posterior three-quarters of the shaft from fibula and tibia. Tendon is very short, passes under a fibrous bridge and then flattens out to pass to usual insertion.

Cracidæ. *Ortalis ruficauda*. *Mitua tuberosa*. *Pauwias galeata*. *Penelope purpurascens*.—In all these the *P. longus* is enormous but chiefly from superficial and fascial origin, the deep origin being just present. The anchor is very broad, short and strong, and the slip to III is good. In some the tendon was ossified down to the anchor. The *P. brevis* was strong, arising from the distal three-quarters of the shaft, from the fibula, adjacent surface of tibia and tibia distal to the end of the fibula. The tendon then passed through a long fibrous bridge, partly calcified in *Ortalis*, and flattened out to usual insertion.

Gallidæ. *Guttera cristata*, *G. edouardi*, and *G. pucherani*. *Meleagris gallopavo*. *Argus giganteus*. *Gallus gallus* (2 examples).

*Calophasis ellioti*. *Crossoptilon mantchuricum* (2 examples). *Rollulus roulroul*. *Ortyx virginianus* (2 examples). *Lophortyx douglasi*. *Coturnix coromandelica*. *Francolinus infuscatus*.—In all these Galline birds the P. longus was enormous, with very strong superficial, well-marked fascial and rather slight deep origins. The anchor was stout and in most cases rather broad and short, but in the Francolin was narrow and rounded. The slip to III was invariably strong. The tendon of the longus was partly ossified down to the anchor in the older birds. The P. brevis was present in all, but in most cases rather slender, and its origin was from the distal three-quarters of the shaft including the fibula, adjacent surface of tibia and tibia distal to the fibula. The rather short tendon (long in one of the Quails) usually passed through a fibrous bridge and then flattened out to normal insertion. In Pucheran's Guinea-fowl, however, the tendon did not pass across the tarsal joint, but ended on a knob on the distal end of the tibio-tarsus in about the position where it occasionally passes through a fibrous or calcified bridge. The P. brevis was relatively weak in all these birds, and the condition in the Guinea-fowl is at least complete functional degeneration, but I have found no case of complete absence, although I examined *Penelope* and *Gallus gallus*, in which Dr. Gadow found it absent.

*Opisthocomi*. *Opisthocomus cristatus* (2 examples).—The P. longus is of moderate size with only a rather narrow superficial origin. Good anchor and slip to III present. The P. brevis is relatively rather strong, arising from the distal three-quarters of the shaft in the normal fashion and with a short tendon flattening out to the usual insertion.

In the Galliformes the P. longus remains the dominant muscle and is always well developed, with, however, seldom much deep origin. The P. brevis is present but obviously less important.

#### GRUIFORMES.

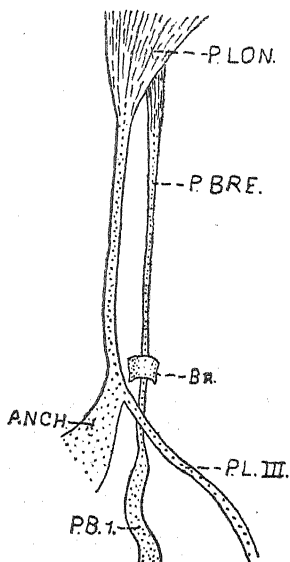
Rallidæ. *Fulica leucoptera*. *Gallinula chloropus* and *G. phænicura*. *Tribonyx mortieri*. *Hydromia alleni*. *Porphyrio porphyrio* (2 examples). *Ocydromus australis*. *Porzana carolina*. *Aramides chiricote* and *A. ypecaha*. *Hypotenidia philippensis* (2 examples). *Rallus longirostris*, *R. maculatus*, and *R. celebensis*.

In all these Rails (text-fig. 183) the P. longus is a strong muscle usually with an extensive superficial and good fascial origin and rather little deep origin. The muscular fibres converge to a powerful tendon, frequently ossified, about the middle of the length of the shaft. The anchor is very strong and tends to be broken into separate slips; the slip to III is always present, with the usual course. The P. brevis is also always present and rather strong, arising from the upper half of the fibula and the adjacent surface of the tibia. It then passes into a stout tendon, sometimes ossified, and having traversed a fibrous or calcified bridge flattens out to the usual insertion. The text-figure, drawn from

a Green-backed Porphyrio, gives the arrangement usual in the Family.

Gruinæ. *Gruinæ*. *Gruis australasiana*. *Anthropoides virgo*. *Balearica chrysopelargus*.—In the Cranes the P. longus is rather large with extensive superficial, fascial and deep origins, very long tendon sometimes ossified, very wide anchor and good slip to III. The P. brevis is present and arises from nearly the whole length of the fibula but is very weak. The tendon, sometimes ossified, has the usual insertion by a flattened extremity which passes under both the slip to III and a very long tarsal ligament.

Text-fig. 183.



Peroneal muscles of *Porphyrio porphyrio*.

Description and lettering as in Text-figure 179 (p. 1041).

Br. Fibrous bridge.

Araminæ. *Aramus scolopaceus*.—The P. longus is large with superficial and fascial origins but without deep origin. It has a stout anchor and good slip to III. The P. brevis is either altogether absent or represented by a very small ligament.

Psophiinæ. *Psophia crepitans*, *P. leucoptera*, and *P. obscura*.—The P. longus is large with chiefly superficial and fascial origins. The anchor is broad and the slip to III is present and stout, but peculiar in so far as after giving off a stout anchor to the perforated flexor of III in the region where it usually fuses with that, it passes on and joins much more distally the tendon of the perforated and perforating flexor of the same digit. The P. brevis

is present, arising from nearly three-quarters of length of the shaft and with usual insertion.

Dicholophidæ. *Cariama cristata* (3 examples).—The P. longus is large with superficial and fascial and slight deep origins and a very long tendon which gives off a very broad anchor and is continued as a slip to III. The P. brevis is represented by a minute muscular head arising from the fibula and tibia opposite the biceps ligament, and a very long slender tendon close to the tibia which after crossing the tarsal joint flattens out to the usual insertion.

Otididæ. *Otis tarda* (2 examples).—The P. longus is very strong with superficial, fascial, and separate deep origins. The tendon is not long and after giving off a broad anchor is continued as the slip to III. The P. brevis was absent.

Rhinocetidæ. *Rhinocetus jubatus*.—The P. longus was very large with all three origins, a stout anchor and good slip to III. The P. brevis was also well developed with an extensive origin along the length of the fibula and adjacent surface of the tibia and had the usual flattened insertion; it appeared to me to be larger in the Kagu than in any of the other Gruiform birds.

Eurypygidæ. *Eurypyga helias*.—The P. longus was well developed with all three origins, a broad anchor and good slip to III. The P. brevis was also relatively strong, arising from the upper half of the fibula and adjacent tibia and passing into a long tendon which flattened out as it approached the normal insertion.

Heliornithidæ. *Heliornis fulica* seu *Podoa surinamensis* (2 examples). *Podica senegalensis*.—The P. longus was large in all these but with only superficial and slight fascial origins, the deep origin being practically absent. The anchor was very broad and strong, but the usual slip to III, although certainly present, was delicate and could hardly have been functional. The P. brevis was large and strong, with a rounded origin from the proximal portion of the fibula, then a very long tendon partly ossified which passed under a partly calcified bridge to flatten out to the usual insertion.

Of the Gruiform birds the Rails and the Kagu seem to present the most generalized condition of the peroneals since both are present and actively functional, the longus being the dominant muscle. In the Cranes, Seriemas and Bustards, the brevis shows signs of disappearing. The Sun-bitterns and the Finfoots stand apart from the others, the former recalling the condition most frequently found in the Limicolæ, and the latter, with the tendency for the longus to be reduced, being quite peculiar in the group.

#### CHARADRIIFORMES.

##### Limicolæ.

Charadriidæ. *Limosa lapponica*. *Actitis hypoleucos*. *Gallinago caelestis*. *Machetes pugnax*. *Scolopax rusticola* (2 examples).

*Himantopus nigricollis*. *Recurvirostra avocetta*. *Hæmatopus ostralegus*. *Vanellus vanellus* (3 examples). *Charadrius plumialis*. *Rhyrchæa capensis*.

In all these the *P. longus* is rather a small muscle with a broad superficial, slight fascial, and very little deep origin from the edge of the fibula. It narrows rapidly to a long tendon which gives off a broad anchor and ends in the usual slip to III. The *P. brevis* is always reduced, arising only from the proximal part of the fibula and passing into a long slender tendon which passes down the leg parallel with the tendon of the *longus*, dips under a fibrous bridge at the distal end of the tibio-tarsus, and then passing under the slip to III flattens out to the usual insertion. In the Avocet, two examples of the Lapwing, and in the Oystercatcher, the *brevis* was reduced to a slender ligament which arose from the distal end of the tibio-tarsal shaft in about the position where it would normally pass through a fibrous bridge, and passed across the tarsal joint to be lost in the fasciæ under the slip to III.

Chionidæ. *Chionis alba*.—The *P. longus* is present with all three origins, the deep being very feeble. The muscle passes into a very long tendon which has the usual broad anchor and slip to III. The *P. brevis* is also present but extremely feeble, a few fibres from the fibula passing into a delicate tendon with the usual insertion.

Glareolidæ. *Glareola pratincola* (2 examples).—Precisely as in *Chionis*, the tendon of the feeble *P. brevis* being still longer and more slender.

Thinocorythidæ. *Thinocorys* ? species.—The *P. longus* is as in the Glareolidæ and Chionidæ, but the *P. brevis* is stronger, with an extensive origin from the fibula passing into a long tendon with usual insertion.

Œdicnemidæ. *Œdicnemus scolopax*.—The *P. longus* is large and strong, with all three insertions passing into a rather shorter tendon with broad anchor and strong slip to III. The *P. brevis* is represented at most by a vestigial tendon.

Parridæ. *Hydrophasianus chirurgus*. *Phyllopezus africanus*. *Jacana jacana*. *Asarcia variabilis*.—In all these long-toed, long-legged Jacanas the *P. longus* is rather large with superficial, fascial, and good deep origins. The broad band of muscle then passes into a very long tendon which gives off a wide but short anchor and is continued as the slip to III. The *P. brevis* arises from the upper third of the fibula and adjacent tibia and gives rise to a very long tendon which flattens out to the usual insertion.

#### Lari.

Laridæ. *Larus argentatus*, *L. ridibundus*.—The *P. longus* has only the superficial origin, and the muscle converges to a very long tendon which gives off a broad anchor and then forms the usual slip to III. The *P. brevis* arises only from a small

proximal portion of the fibula and then forms a very long tendon which runs down the leg parallel with the tendon of the longus, dips under the slip to III, and has the usual flattened insertion.

*Alcidæ. Alca torda.*—The *P. longus* is fairly large, with superficial and fascial origins, then a long tendon which gives off a broad anchor and ends as the normal slip to III. The *P. brevis* is also rather strong but much inferior to the longus. It has an extensive origin from the fibula and then passes into the usual tendon with normal insertion.

*Pterocles. Pterocles alchata* (2 examples).—The *P. longus* is broad and rather strong, with all three origins and broad anchor and slip to III. The *P. brevis* is absent, so that in this respect the Sand-Grouse agree with the general tendency of the plover-like birds and differ from the game-birds.

*Columbæ. Sturnoenas cyanocephala. Leucosarcia picata* (2 examples). *Phlogoenas cruentata* and *P. luzonica. Geophaps plumifera. Phaps chalcoptera* and *P. elegans. Columba picui. Geopelia cuneata* and *G. tranquilla. Zenaidura carolinensis. Carpophaga rufigula. Columba livia* (many examples, wild and domestic). *Osmotreron bicincta* (2 examples).

The Doves and Pigeons present an interesting series of modifications. A state of affairs very closely resembling what occurs in Limicolous birds is not infrequent. In *Leucosarcia*, for instance, the *P. longus* is very strong, with good superficial and fascial origins and a considerable deep origin from the proximal portion of the fibula. The muscular mass narrows to a very long tendon, which eventually gives off a broad anchor and runs on to form a good slip to III. The *P. brevis* similarly arises chiefly from the proximal portion of the fibula and the adjacent surface of the tibia, passes into a long tendon which after traversing a fibrous bridge flattens out to the usual insertion. The *P. longus* is definitely the dominant muscle, but the *brevis* is well formed and functional. In *Columba* the conditions are similar, but the extent of the fibular or deep origin of the longus varies, and the length of the tendon varies inversely with it. In *Carpophaga* the fibular origin of the longus is still more important, and in many of the smaller Pigeons and Doves, and in *Osmotreron*, the deep origin is the more important, the superficial and fascial origins getting weaker; the tendon is shorter, but the whole muscle is relatively feebler. So also in the smaller Doves and Pigeons, the *P. brevis* tends to degenerate, arising only from the lower end of the fibula and the tibia distad of this, so that the tendon is very short and very different from the typical Limicoline condition. On the other hand, in *Osmotreron*, the *P. longus* has become smaller and reduced to its deep origin with a relatively short tendon, but the *P. brevis* has increased in size and is actually stronger than the longus.

In Charadriiform birds generally the *P. longus* is the dominant muscle and the *P. brevis* tends to become weaker or to disappear.

In the case of both muscles, the normal arrangement is for the muscular bellies to be limited to the proximal portion of the leg and to give rise to very long tendons. The Pigeons and Doves show the type of the Charadriiform group, but also indications of moving away from it.

In the Alectoromorph group generally, the *P. longus* remains as the dominant muscle and, except in the aberrant Finfoots, is always large and powerful. The *P. brevis* varies, sometimes being very feeble or absent, but in some of the Columbæ, as an exception, shows signs of outstripping the *P. longus*. The great lengthening of the tendons of both muscles in some of the Ralliform and most of the Charadriiform birds may easily be regarded as in correlation with the long legs of these birds. It is interesting to note that the Columbæ show signs of a former long-legged Charadriiform condition.

#### CORACIOMORPHÆ.

##### CUCULIFORMES.

##### Cuculi.

Cuculidæ. *Cuculus canorus* (2 examples). *Guira piririqua* (2 examples). *Hierococcyx varius*.—In the Guira cuckoo the *P. longus* is a large muscle with good superficial, fascial, and deep origins. Its tendon gives off a long narrow anchor and then passes on to form the slip to III. In *Hierococcyx* the *longus* is relatively smaller and the anchor is broader. In *Cuculus* the deep origin is much the most important, and is chiefly from the distal end of the shaft. In all the *P. brevis* is well developed, with a strong origin from the tibia below the fibula and a varying extension up the fibula. The tendon of insertion runs the usual course under the slip to III, and flattens out to an insertion placed so that the muscle not only flexes the foot but has a considerable power of rotation.

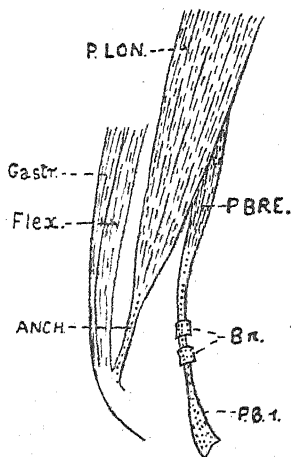
Musophagidæ. *Corythaix persa* (2 examples). *Turacus corythaix*.—The *P. longus* is a large muscle with extensive superficial and fascial origins and a small deep origin extending down the fibula. The anchor is very broad, and the slip to III well marked. The *P. brevis* is a long rounded muscle arising from about the distal three-quarters of the length of the shaft, from the fibula and tibia below the fibula. The tendon passes through a fibrous bridge and then flattens out to the usual insertion.

In the Cuculi the *P. longus* remains the dominant muscle, but there are signs of its being reduced to a deep origin with corresponding increase of the importance of the *P. brevis*. The group shows, in fact, a transition from the condition which I regard as more generalized towards the particular type of specialization which becomes more and more marked in other Coraciomorphines.

Psittaci. *Stringops habroptilus*. *Melopsittacus undulatus*. *Nymphicus uvaeensis*. *Nanodes (Lathamus) discolor*. *Cyanorhamphus alpinus*. *Platycercus eximius*. *Aprosmictus cyanopygius*. *Palaeornis fasciata*. *Eclectus pectoralis* (2 examples), *E. roratus*. *Paeocephalus meyeri*. *Caica melanocephala*. *Pachynus brachyurus*. *Chrysotis* (? species). *Myopsittacus monachus*. *Conurus jendayi*. *Calopsittacus novae-hollandiae*. *Cacatua sulphurea*. *Trichoglossus novae-hollandiae*. *Lorius domicella*.

Parrots carry further the specialization of the generalized type which is already indicated in the Cuculi. In every case both muscles are present, but there are different degrees to which the longus is reduced and the brevis increased. In *Stringops* (text-fig. 184) the P. longus is a large muscle with good superficial and fascial origins and a deep origin extending nearly the whole length of the shaft. The muscular belly narrows to a short tendon which is inserted to the capsule of the flexor tendons representing what I term the anchor in this memoir. A few

Text-fig. 184.

Peroneal muscles of *Stringops habroptilus*.

Description and lettering as in Text-figure 179.

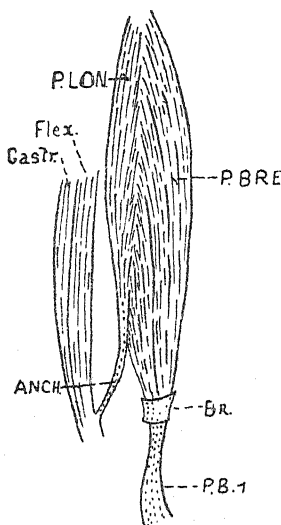
Br. Fibrous bridges.

delicate strands can be made out passing in the direction of the usual slip to III, but that structure is certainly absent functionally, even if there be a trace of it morphologically. I have found a small superficial origin of this muscle in several other Parrots; it was relatively large in *Calopsittacus*, and present in *Cyanorhamphus* and *Caica*. Usually, however, it has been lost, and the normal condition in Parrots is for the P. longus to be reduced to a deep origin. This may be large as in *Eclectus*, long but slender as in *Platycercus*, or it may be so small as in



*Chrysotis* and so closely attached to the fasciæ of the P. brevis that Dr. Gadow has described it as fused with that muscle. I found a minute but distinct slip to III in *Calopsittacus novaehollandiæ*, and faint traces of fibres in the direction usually taken by that slip in *Caica*, *Myopsittacus*, and one or two others. The P. brevis in *Stringops* (text-fig. 184) is a stout rounded muscle arising from high up the shaft and passing into a strong rounded tendon, which after traversing two fibrous bridges flattens out to the usual insertion. In most cases, however, it is much stronger than the P. longus, arising from the whole length of the fibula below the biceps insertion, from the adjacent area of the tibia and from the tibia distad of the

Text-fig. 185.

Peroneal muscles of *Platycercus eximius*.

Description and lettering as in Text-figure 179.

Br. Fibrous bridge.

fibula. Its strong tendon usually passes under a fibrous bridge and has the normal flat insertion to the proximal end of the tarsus-metatarsus shaft. *Platycercus* (text-fig. 185) shows the most usual condition of this muscle in Parrots. In *Trichoglossus* and some others the P. brevis is even larger, arising from the head of the fibula proximad of the biceps insertion.

Parrots thus show conditions of the peroneals which link them with the arrangements found in the groups I have already discussed, but as a group are moving away from the normal type in the Coraciomorphine direction.

The Cuculiformes retain marked indications of their former

possession of the generalized condition of the peroneals, but have moved away from that condition, the Parrots further than the Cuckoos and Plantain-eaters.

#### CORACIIFORMES.

##### Coraciæ.

Coraciidæ. *Coracias garrula*, *C. indica* (2 examples). *Eurystomus orientalis*.—The *P. longus* is rather weak, but retains a small superficial, fascial, and slight deep origins. The anchor is very short, and the slip to III is extremely slender but present, at least occasionally. The *P. brevis* is stronger than the *longus*; it arises from about the distal three-quarters of the shaft, from the fibula and tibia, passes under a fibrous bridge and is inserted by the normal flat tendon.

Momotidæ. *Momotus lessoni* and *M. subrufescens*. *Aspatha gularis*.—In these the *P. longus* is well developed with all three origins. It has a short anchor and is continued as a good slip to III. The *P. brevis* is large and its tendon is just stronger than that of the *longus*. It arises from the proximal half of the fibula with the adjacent surface of the tibia and gives rise to a rather long, rounded tendon which flattens out at the normal insertion.

Alcedinidæ. *Alcedo ispida* (2 examples), *A. asiatica* and *A. bengalensis*. *Ceryle alcyon*, *C. americana*, *C. inda*, and *C. maxima*. *Ceryx rufidorsa*. *Cittura cyanotis* and *C. sanghirensis*. *Dacelo gigantea* (3 examples). *Halcyon pileata* and *H. rufa*. *Sauropatis chloris*, *S. sancta*, *S. sordida*, and *S. vagans*.—As I have already pointed out in an account of the Anatomy of the Kingfishers ('Ibis,' 1901, p. 97), the *P. longus* is present in Kingfishers but is plainly degenerating, possibly in association with the degeneration of the fibula. It is best-marked in *Dacelo*; certainly I cannot confirm Beddard's statement ('Structure and Classification of Birds,' p. 199) that it is absent in that bird, and he makes no mention of its presence or absence in other Kingfishers. It has a superficial origin reduced to a narrow tendon from the external corner of the tibial crest, joined by a few fibres from the tibia along the region of the fibula representing the normal deep origin. It is inserted to the capsule of the flexor muscles, this being the usual anchor, but there is no trace of a slip to III. This is the most common condition, but in a few, notably *Ceryle*, *Halcyon*, and *Ceryx*, the muscle is reduced to a simple tendon with only a few muscular fibres, the insertion being the anchor. The *P. brevis* is always present and strong, arising from the area of the tibia usually covered by the lower end of the fibula and passing into a stout tendon which flattens out to the usual insertion.

Meropidæ. *Merops apiaster*, *M. philippensis*.—The *P. longus* is present but is very much reduced, having only a narrow superficial and a few fibres of deep origin. A very short anchor is present, and the slip to III although present is very slender.

The *P. brevis* is much stronger, with a good muscular origin from the distal three-quarters of the shaft; its tendon passes under a fibrous bridge and flattens out to the usual insertion.

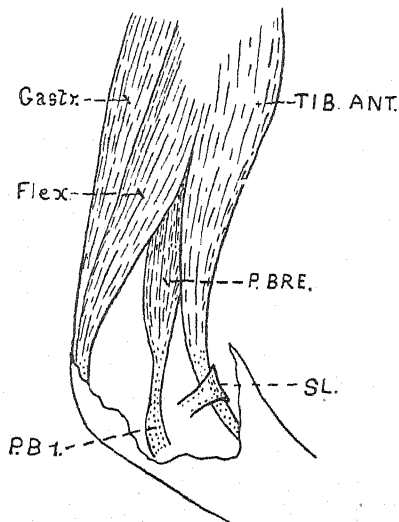
#### Upupidae.

Upupinae. *Upupa epops* (2 examples).—The *P. longus* is absent. The *P. brevis* is large, from the distal three-quarters of the shaft, including both fibula and tibia. The tendon flattens out to the normal insertion.

Bucerotinae. *Bucorvus* (? species). *Rhytidoceros undulatus*. *Lophoceros erythrorhynchus*.—In the Hornbills the *P. longus* is absent, although I find in my notes that there is a degenerate set of tendinous fibres which might possibly represent a vestige of it. The *P. brevis* is very strong, arising from the lower half of the shaft, from the fibula and its fibrous continuation, and from the adjacent surface of the tibia. The strong tendon flattens out to form the usual insertion. In *Bucorvus* the *P. brevis* was equally strong but rather shorter.

Striges. *Athene noctua* (3 examples). *Bubo lacteus* (2 examples), *B. maculosus*, *B. maximus* (2 examples). *Asio otus*.

Text-fig. 186.



Peroneal muscles of *Strix flammea*.

Right leg, outer view. Muscle striped; tendon dotted.

*P. BRE.* Peroneus brevis. *P. B. 1.* Tendon of *P. brevis*.

*Gastr.* External head of Gastrocnemius.

*Flex.* Flexor muscle of foot.

*Tib. Ant.* Tibialis anticus.

*SL.* Sling of tibialis anticus.

*Strix flammea*. *Speotyto cunicularia*.—There is no trace of the P. longus in any of the Owls. The P. brevis is enormous, but usually arises only from the tibia below the fibula. In *Strix flammea* (text-fig. 186) it is relatively longer, arising from all the fibula distad of the insertion of the biceps, from the adjacent tibial surface, and from the tibia distad of the end of the fibula. In *Athene* it is equally long. The stout tendon flattens out after passing through a fibrous bridge (absent in *Strix*) and is inserted in the normal fashion to the proximal end of the tarsus-metatarsus. Its chief action is to rotate the foot on the tibial shaft so as to depress the great toe side and elevate the fourth digit side. It comes into action after the enormous tibialis anticus has flexed the foot.

### Caprimulgi.

Steatornithidæ. *Steatornis caripensis*.—The P. longus is absent. The P. brevis is large and strong, with origin from high up the shaft from both fibula and tibia and fairly long tendon which flattens out to usual insertion.

Podargidæ. *Podargus curvieri*. *Nyctidromus albicollis*. *Egotheles novæ-hollandiæ*.—In *Podargus* the P. longus has a broad superficial origin with no fascial or deep origin. It gives off a broad anchor and is continued as a slender slip to III. The P. brevis is stronger than the longus. It arises from fibula and tibia just below the insertion of the biceps, and its rounded muscular belly passes into a stout tendon which flattens out to the usual insertion. In *Nyctidromus* the P. longus is practically the same as in *Podargus*, but the P. brevis is absent. In *Egotheles novæ-hollandiæ* the P. longus is absent, and the P. brevis is well developed, as in *Steatornis*.

Caprimulgidæ. *Caprimulgus europæus*.—The P. longus is large with superficial, fascial, and deep origins. It has a broad anchor and a good slip to III. The P. brevis is absent.

I have followed the usual arrangement of the genera of Caprimulgi that I have examined, and certainly I do not propose to rearrange them simply on the evidence of the peroneal muscles. It is plain, however, that so far as these muscles are concerned, *Podargus* has remained in the primitive condition, with both muscles present and normal; *Steatornis* and *Egotheles* have specialized in the same direction as the Owls, by losing the P. longus; *Caprimulgus* and *Nyctidromus* present a condition very aberrant amongst Coraciiform birds, and by retaining the P. longus and discarding the P. brevis recall the condition which frequently occurs in the great assemblages which I have already passed in review.

### Cypseli.

Cypselidæ. *Cypselus apus*.—The P. longus is absent. The P. brevis is large and strong, from the proximal end of the shaft including the head of the fibula and adjoining area of the tibia down three-quarters of the shaft, then a very strong tendon

passing over the bridge of the tibialis anticus to usual flat insertion.

Trochilidæ. *Amazilia felicieæ*.—The *P. longus* was absent and the *P. brevis* exactly as in the Swift.

Coli. *Colius capensis*.—The *P. longus* was present in a vestigial condition, with only superficial origin and a slender tendon ending in the anchor, with no slip to III. The *P. brevis* was very large and strong, arising from nearly the whole length of the shaft, involving both fibula and tibia. Its strong but rather short tendon flattened out to the usual insertion.

Trogones. *Trogon puella* and *T. atricollis*.—The *P. longus* was present but not so large as the *P. brevis*; its origin is chiefly deep, and it has a broad anchor and fair slip to III. The *P. brevis* is very large and strong, arising from the greater part of the length of the shaft and ending in a short but stout tendon which flattens out to the usual insertion.

### Pici.

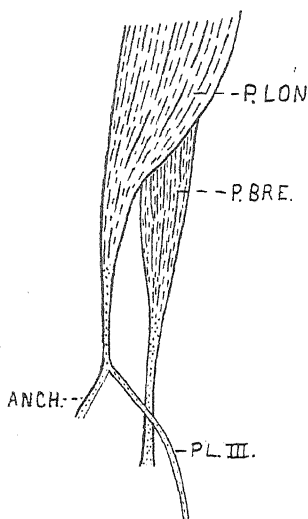
Galbulidæ. *Galbula albirostris*, *G. rufiventris*. *Urogalba paradisea*.—My material for examining these was not good, consisting of partly dissected specimens which had been in spirit for many years. The *P. longus* was certainly very small, but there was a distinct tendon running to form an anchor, and in one case a trace of the slip to III. The *P. brevis* was larger than the *longus* and had a stout tendon flattening out to the usual insertion. I should be glad, however, to examine fresh specimens.

Capitonidæ. *Megascops virens*. *Cyanops flavifrons*.—The *P. longus* was a large muscle with a wide superficial, and short fascial and deep origins. The triangular muscular belly rapidly narrowed to a stout tendon, which, however, was not so strong as the tendon of the *brevis*, gave off a long and rather narrow anchor and was continued as a good slip to III. The *P. brevis* arose from the fibula beginning just below the biceps tendon, and from a considerable part of the tibia, and passed into a strong tendon which flattened out to the usual insertion. (Text-fig. 187.)

Rhamphastidæ. *Aulacorhamphus prasinus*. *Pteroglossus in-scriptus*. *Rhamphastos discolor* (2 examples). *Selenidera maculirostris* (2 examples).—In all these Toucans (text-fig. 188) the *P. longus* was of fair size but with chiefly fascial and long deep origins. The short tendon gave off a narrow anchor and was continued as a slender slip to III. The *P. brevis* was a stronger muscle, its stout tendon forming the axis of a muscular mass arising from the tibia and fibula for three-quarters the length of the shaft. The tendon then passed through a strong fibrous bridge and had the normal flat insertion.

Picidæ. *Dendrocopos major*. *Brachypternus aurantiacus*. *Colaptes mexicanoides*. *Gecinys vittatus*. *Hypoxanthus rivoliæ*.—In the Woodpeckers I found the *P. longus* always present but rather weak and with chiefly superficial origin. Its tendon was very thin and flat and formed the usual anchor, and gave off a thin

Text-fig. 187.

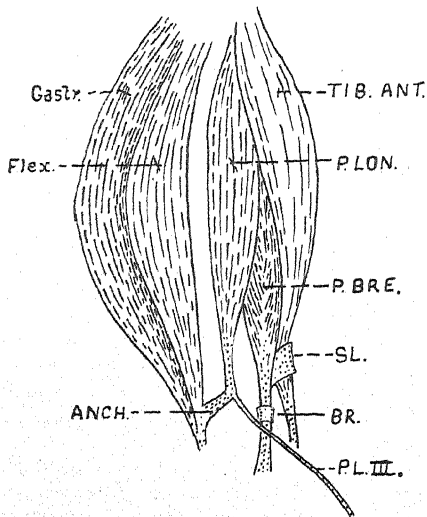


Peroneal muscles of *Megaloma cirens*.

Right leg, outer view. Muscle striped; tendon dotted.

P. LON. Peroneus longus. ANCH. Anchor to Sustentaculum. PL. III. Slip to Flexor of III toe. P. BRE. Peroneus brevis.

Text-fig. 188.



Peroneal muscles of *Rhamphastos discolor*.

Description and lettering as in Text-figure 186 (p. 1061).

P. LON. Peroneus longus. ANCH. Anchor. P. L. III. Slip to III.

strand which in a fresh example of *Dendrocopus* formed the usual slip to III, but which in the other Woodpeckers, of which I had only very old spirit specimens, I could not trace completely to their insertion. The P. brevis was strong, arising from the distal three-quarters of the shaft, and ending in a short tendon which flattened out to the usual insertion.

The Coraciiform birds form an interesting and difficult series, but it is clear that the general tendency in the group is for the P. brevis to increase and for the P. longus to be reduced. The series, however, is not very coherent. A certain number have remained almost in the generalized condition with the P. longus possibly slightly reduced in its origin and equal to or weaker than the P. brevis, but showing the anchor and slip to III, and with the P. brevis a strong but not excessively strong muscle. These central types are the Coraciæ, Momotidæ, Meropidæ, *Podargus* amongst the Caprimulgi, and the Trogones, Capitonidæ, and Rhamphastidæ. In others the P. longus is still further reduced and has lost the slip to III, whilst the P. brevis has relatively still further increased. These are the Alcedinidæ (Dr. Gadow, however, states that *Pelargopsis* has proceeded still further to the complete loss of the P. longus), the Colii, the Galbulidæ (probably), and most of the Picidæ. In yet another set the specialization has proceeded to the complete loss of the P. longus, and the P. brevis is always very strong. These are the Bucerotidæ, Upupidæ, Striges, and, amongst the Caprimulgi, *Steatornis* and *Egotheles*, the Cypselidæ and the Trochilidæ. Finally, in *Nyctidromus* and *Caprimulgus*, although the P. longus is partly reduced, the P. brevis is absent.

#### PASSERIFORMES.

##### Passeres Anisomyodæ.

Subclamatores. *Eurylemus ochromelas*. *Cymbirhynchus macrorhynchus*.

Clamatores. *Picolaptes affinis*. *Chasmorhynchus nudicollis*. *Tyrannus melancholicus*. *Myiarchus tyrannulus*. *Pitangus sulfuratus*. *Pitta strepitans*.

##### Passeres Diacromyodæ.

Suboscines. *Menura superba*.

Oscines :—

Corvidæ. *Cracticus destructor*. *Creadion carunculatus*. *Cyanocorax luxuosus*.

Paradisidæ. *Parotia lawesii*. *Alurædus melanocephalus*.

Sturnidæ. *Enodes erythrophrys*. *Mimo dumonti*. *Acridotheres fuscus*.

Icteridæ. *Icterus jamaicæ*. *Ostinops decumanus*.

Ploceidæ. *Estrela phœnicotis*.

Tanagridæ. *Tanagra sayaca*. *Rhamphocœlus brasilius*.

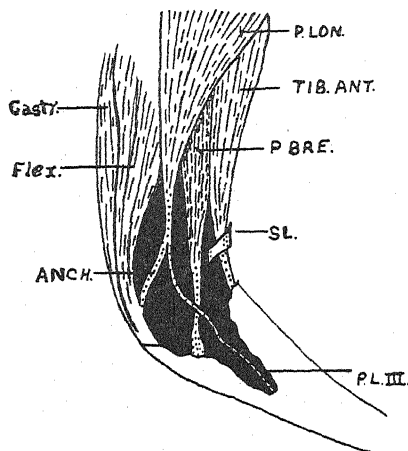
Cœrebidæ. *Cœreba cyanea*.

Meliphagidæ. *Entomyza cyanotus*. *Acanthorhynchus* (2 species).

- Nectariniidæ. *Arachnechthra zeylonica*.  
 Troglodytidæ. *Campylorhynchus unicolor*.  
 Hirundinidæ. *Hirundo rustica*.  
 Laniidæ. *Lanius excubitor*.  
 Artamidæ. *Artamus leucogaster*.  
 Dicuridæ. *Dicurus* (? species).  
 Oriolidæ. *Oriolus galbula*.  
 Parridæ. *Liothrix luteus*.  
 Turdidæ. *Turdus tristis*. *Merula tamaulipensis*. *Geocichla citrina*. *Mimus orpheus*.

The Passeriform birds that I examined were well distributed over the divisions into which systematists have attempted to divide this group, and presented a fair sample of the manifold types of habit and size that occur in the group, a sample that I take to be fairly representative, as I found extremely little divergence. The type which recurs throughout the group with a uniformity that is almost tiresome, is well shown in the figure of *Parotia lawesii* (text-fig. 189). Both peroneals are present, well

Text-fig. 189.

Peroneal muscles of *Parotia lawesii*.

Description and lettering as in Text-fig. 188 (p. 1064).

developed and functional. The longus has a broad superficial, good fascial, and fairly long deep origins; the muscular mass is an elongated triangle which ends in a short tendon which almost at once forks, the shorter and stouter fork forming a long narrow anchor, the other forming the "slip" to III. This "V"-shaped forking is very different in appearance from the broad and short anchor which is the more common type in other groups, but it occurs also in other birds and can be regarded only as typically not characteristically passerine. The P. brevis arises from the



fibula below the insertion of the biceps tendon and from the adjacent surface of the tibia; the fusiform belly gives rise to a short tendon which frequently, but not invariably, traverses a fibrous bridge and then flattens out to the normal insertion to the proximal end of the tarsus-metatarsus.

The minor differences which are to be found, but too irregularly to be correlated with size, habit, or systematic position, relate to the relative sizes of the two muscles. Sometimes the *P. longus* is rather feeble with little deep origin and a relatively narrow superficial origin; the *P. brevis*, on the other hand, becoming very thick and strong. The muscular bellies of both muscles may be shorter and their tendons longer.

In only two of the Passeriform birds examined did I find notable differences. In *Menura superba*, the inclusion of which amongst the Passeriformes I doubt on other grounds, the anchor of the *P. longus* was much shorter and rather wider than usually occurs in the group, and the *P. brevis* was relatively considerably weaker. In *Hirundo rustica* the *P. longus* had the usual broad superficial origin but very little deep or fascial origin, and the slip to III was absent. The *P. brevis* was of the usual Passerine type and relatively weaker than in the Swifts.

The Coraciomorphine birds present many different phases of the degeneration of the longus and of the increasing importance of the brevis, and in this respect are in marked contrast with the other Legions into which Dr. Gadow has arranged the Orders of birds.

#### SUMMARY AND CONCLUSIONS.

The Peroneus longus muscle shows every gradation from elaborate structure and apparently important function to complete absence, and the facts fall into a coherent picture if we suppose that we have to deal with loss of parts originally present. The presence and absence of origin from the fasciæ of the neighbouring muscles are the most irregular and may well be interpreted as in direct relation to function. If the muscle be large and important, it overgrows its bounds and comes in organic contact with the adjacent fasciæ; if it is smaller and less important it remains isolated. When the muscle as a whole appears to be in process of degeneration, this may proceed in two ways. Occasionally, but rarely, the deep origin begins to disappear first, and the superficial origin gradually narrows until it becomes only a thin superficial tendon. More often the process starts with the degeneration of the superficial origin, and this is often accompanied by strengthening and lengthening of the deep origin, until finally nothing but the deep origin is left. This next gradually shortens until the whole muscle disappears. Of the tendons of insertion, the slip to III goes first and the anchor persists. There are many cases in which the slip to III has been lost, the anchor remaining as the only insertion, but I have found no instance in which the anchor has disappeared leaving only the

slip to III. The pull on the anchor by the contraction of the muscle not only straightens the tarsal joint, but steadies the sustentaculum and therefore assists the action of all the flexors of the toes; the slip to III acts merely as an accessory to the proper flexor of the third toe.

I find the *Peroneus brevis* very difficult to understand. Its rotating action is often extremely slight, and in its action in flexing the tarsal joint it appears to do little more than assist the much more powerful *tibialis anticus*, the mechanical arrangement of which is more favourable. So far from it being surprising to find that it has degenerated or completely disappeared in so many groups, it is remarkable that it should have been preserved at all. In the cases in which it has become stronger and has surpassed the *longus*, it seems to me that its power of rotation is greater, and in a number of cases, particularly in *Passerines*, its contraction appears to have the effect of partly flexing the toes and the great toe, as if its action would assist in perching. I am afraid, however, that an equally elaborate investigation of all the muscles of the lower leg would be necessary before the varying conditions of the *peroneals* could be interpreted in terms of function.

On the information at my disposal I find it extremely difficult to associate the conditions of the *peroneal* muscles with differences in habit that point directly to functional adaptation. On the other hand, with a few, a very few, exceptions to which I shall refer later, there is a close conformity between the condition of the *peroneals* and what appear to be the most securely founded systematic divisions. Birds seem to have this or that type of *peroneal* muscle, not because they are arboreal or terrestrial, swimmers or waders, scratchers, predatory or vegetarian, but because it is the type occurring in this or that systematic division. Whatever be their habit they seem to make shift with the type of *peroneal* which occurs in their group. All the four Legions into which Dr. Gadow groups the Orders of *Carinate* birds, and most of the orders themselves, show certain members with what I have assumed in this paper to be the generalized, possibly the more ancestral condition of the *peroneals*, and all show signs of moving in a definite direction away from this generalized condition. In the *Ratites* the *longus* is dominant but the group has moved away from the central type by extreme reduction or total loss of the *brevis*. Of the *Colymbomorphæ* the *Penguins* show the central type, the *Grebes* have a weak *longus* with the slip to III occasionally absent, but the *brevis* is always rudimentary or absent. In the *Petrels* the *longus* has always at least a superficial origin, the anchor and slip to III, but the *brevis* has relatively increased in size. In the *Pelargomorphæ* (except *Pandion*), the *longus* remains the dominant muscle and always has both the anchor and the slip to III, and the *brevis*, except in the *Falconiformes*, tends to disappear. Some *Steganopods*, *Hérons* and *Ibises*, *Screamers*, and *Ducks* and *Geese* remain in the central position. Other *Steganopods* and *Storks* and *Flamingos* have

lost the brevis altogether. The Falconiformes show an interesting series. *Serpentarius* is in quite the central position; in *Cathartæ* the superficial origin of the longus is slightly reduced, but the muscle remains the dominant of the pair. In the Falconidæ (omitting *Pandion*) the superficial origin and the longus generally tend to be reduced, but the anchor and slip to III always persist and are strong and functional; the brevis increases greatly and may equal or surpass the longus. In so far the Falconiformes present a parallel with the Owls, but are to be distinguished from that group by the retention of the longus with its anchor and slip. In the Alectoromorph Legion the great majority remain in the central condition. The longus is invariably present, the superficial origin is almost invariably the stronger, the anchor is always present and the slip to III absent only in the Heliornithidæ. The brevis is almost invariably the weaker muscle and shows a strong tendency to disappear, *e. g.* among the Tinamidae it may be excessively feeble, it is feeble or degenerate in some Galliform birds, absent or reduced in some Gruidæ and some Charadriidæ. The Columbæ are specially interesting; the longus is always present with anchor and slip to III, but there seems to be a tendency for it to be reduced and for the brevis to increase, especially in the smaller and most Passerine-like Pigeons.

In the Coraciomorphine Legion the characteristic tendency is for the reduction of the longus at the expense of the brevis. The Orders, however, show marked differences in the extent to which this process has occurred. Of the Cuculiformes, the Cuckoos and Plantain-eaters remain almost in the central condition, and, although the brevis is always well developed, it is surpassed by the longus. The Parrots, like the Pigeons, show within the group all stages from an almost central condition where the longus is complete and surpasses the brevis, through stages in which the longus is still well developed, although it has lost the slip to III, to the final stage in which there is almost no trace of the longus remaining. The Coraciiformes have moved furthest from the central condition. A very few, the Motmots, some of the Kingfishers, *Podargus* among the Caprimulgi, and Trogons and Barbets show almost the central condition, but even amongst them the longus is usually very little superior to the brevis, although it retains its parts. In most Coraciiformes the longus is at least feeble, has usually lost its slip to III and is often entirely absent. The Passeriformes, on the other hand, are remarkably constant and very near the central condition, although the brevis may equal or nearly surpass the longus, and in one case (*Hirundo*) the slip to III has been lost. In the diagram reproduced as text-fig. 190, I have endeavoured to show in a diagrammatic fashion the general trend of the modification of the peroneals in the groups of birds. The central space represents the central or primitive condition, the area to the left the degeneration of the brevis, that to the right the degeneration of the longus. The placing of the named enclosures represents roughly the position

of the different groups with regard to the central avian condition. It is to be noted that nearly every group seems to have made experiments in both directions, but as we read from above downwards in the diagram, we pass from movement towards the left to movement towards the right. And it may also be noticed that, in a general way, what are usually regarded as the groups exhibiting the lower modifications of avian structure are towards the top of the diagram, those representing the higher types towards the bottom. If I had felt justified in expanding this diagram, by placing the names of the minor groups in their proper orientation with regard to the peroneals, it would have been found in the same fashion, that inside each group, on the whole, those which are generally regarded as the higher types were towards the right hand side of the spaces, those representing the lower types towards the left hand. In other words, I think I may say that the higher types of avian modification are associated with a tendency for the degeneration of the *Peroneus longus* and an increase of the *Peroneus brevis*.

Adaptation, direct or associated, may be the fundamental explanation of the facts that I have tried to set out, but it is difficult to follow, and it is easy to see that kinship appears to be a more important factor. The Eagles and Vultures have many adaptive resemblances with the Owls, but the former contain members directly linking them with the primitive condition and have never moved far from it, and the latter show the extreme modification of the Coraciiform group. Swifts and Swallows have many points in common, but the former, in the condition of the peroneals, are extreme Coraciiform birds, the latter very slightly modified from the true Passerine condition. So also Humming-birds are extreme Coraciiformes in this respect, and Sun-birds are true Passerines. The family tradition appears even in many of the minor changes; all the Storks have lost the *brevis* and the Herons have retained it.

There remains to say a word as to the few birds which do not lie comfortably, so far as the peroneals are concerned, in the positions usually assigned them. In a memoir dealing with a similar large series of facts in bird anatomy ("On the Intestinal Tract of Birds," Trans. Linn. Soc., Zool. viii. p. 173), I pointed out what seems a logical necessity (frequently, however, overlooked by those who use anatomical characters for systematic purposes), that if we have reason to believe a particular character to have been ancestral, we cannot assume that animals now without it are more nearly allied than those that have retained it. There is no *a priori* ground for assuming that it may not have been lost twice or several times independently. It follows therefore that the loss of the *longus* muscle, or of any important part of it, or of the *brevis* muscle, is no valid clue to systematic position.

It is equally clear that the common retention of the ancestral condition is no ground for placing the descendants of a particular ancestral stock together, if relative affinity and not convenience is to be the basis of classification.

A glance at the table (text-fig. 190) will show why anatomists on the hunt for convenient systematic characters would take

Text-fig. 190.

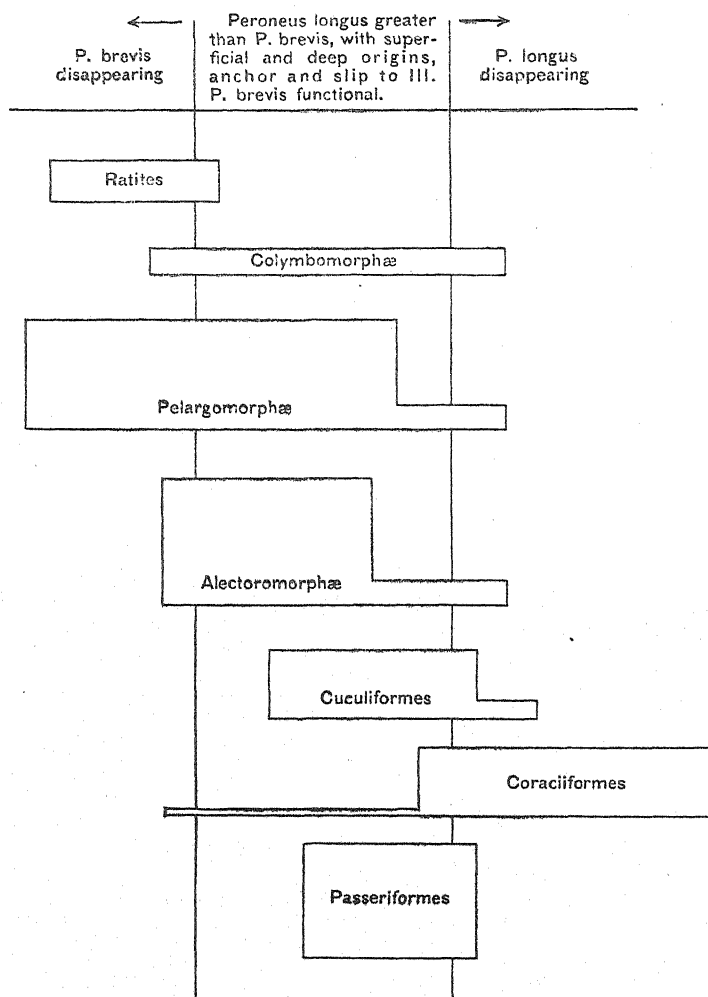


Diagram of Peroneal muscles in Birds.

The central space represents the condition regarded as primitive in this memoir, the *P. longus* being fully developed, with superficial and deep origins, anchor and slip to III, and stronger than the *P. brevis*, which, however, is present and functional. The various enclosures represent the groups of birds indicated by the lettering. Coincidence with the central space indicates that the primitive condition of the peroneals is present; displacement towards the left indicates reduction of the *P. brevis*, displacement to the right reduction of the *P. longus*.

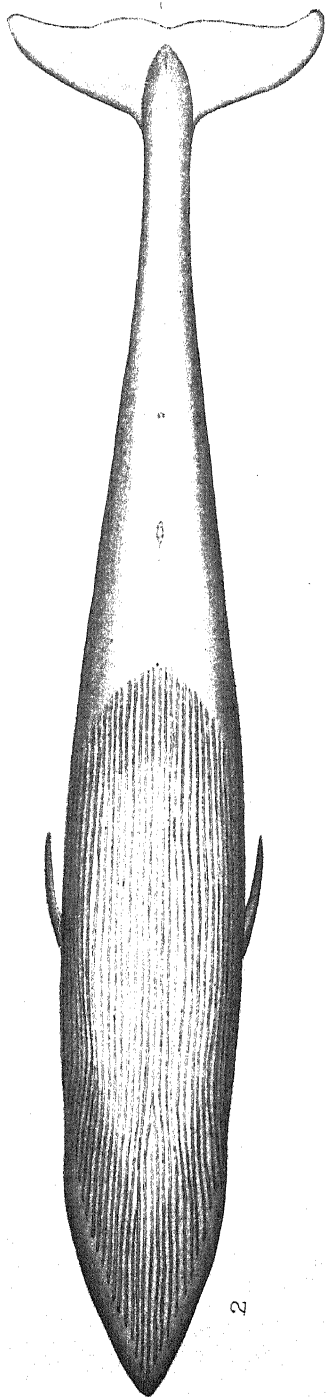
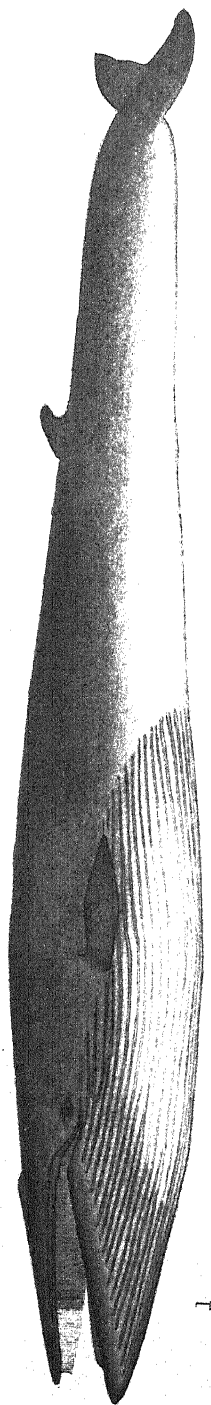
little interest in the peroneals. Some of the Colymbomorphs, most of the Pelargomorphs, most of the Alectoromorphs, most of the Cuculiformes, a few Coraciiformes, and most of the Passeriformes would have to be placed together. We know from other reasons that the association would be absurd, but it is not more illogical than to place *Ornithorhynchus* and *Echidna* in the same Order because they have retained a reptilian legacy that was probably once the common property of all mammals. The Ratites, some of the Colymbomorphs, some of the Pelargomorphs, and a few of the Alectoromorphs would have to be placed together because of the absence of the *brevis*. Some of the Colymbomorphs, and a few Pelargomorphs, a few Alectoromorphs, a few Cuculiformes, most of the Coraciiformes, would similarly have to be placed together because of their loss of the *longus*. A rather tedious piece of work may be of some use, if only it serve to direct attention to the confusion that must arise if characters be not carefully analysed before they are employed for systematic purposes, and to the information which apparently unruly facts may afford, if they are plotted out over a sufficiently comprehensive field.

On the other hand, although the common retention and common loss of ancestral character are no proof of affinity, I myself, like most anatomists who have taken an interest in trying to correlate their facts, have been impressed by the fashion in which allied animals march along the path of modification in the same direction. I have found this to be the case in Pigeons (Journ. Linn. Soc., Zool. xxvii. p. 210), in Kingfishers ('Ibis,' 1901, p. 97), in Gruiform birds (P. Z. S. 1901, p. 629), and in Limicoline birds (P. Z. S. 1905, p. 155), and the general results which I have been stating in this communication point in the same direction. It appears to me therefore that the existence of notable unconformity at least suggests that the position assigned in the System calls for enquiry.

The first notable instance is *Pandion*, which in the matter of the peroneals differs from all the Eagles and Vultures and conforms with the Owls. I cannot find that this point in its structure has been recorded previously, but many systematists have seen in *Pandion* a link between the nocturnal and diurnal birds of prey, and others have actually placed it amongst the Owls. The question calls for re-examination.

I am less impressed with the cases of *Nyctidromus* and *Caprimulgus*. So far as the *longus* is concerned they agree closely with *Podargus*, but although the latter, like all other Coraciomorphine birds, has a well-developed *brevis*, the two former have no *brevis*. I have already pointed out that at the best the action of the *brevis* is difficult to understand, and appears to be frequently superfluous. I am therefore of the opinion that its loss in these isolated cases, however curious, is insignificant.

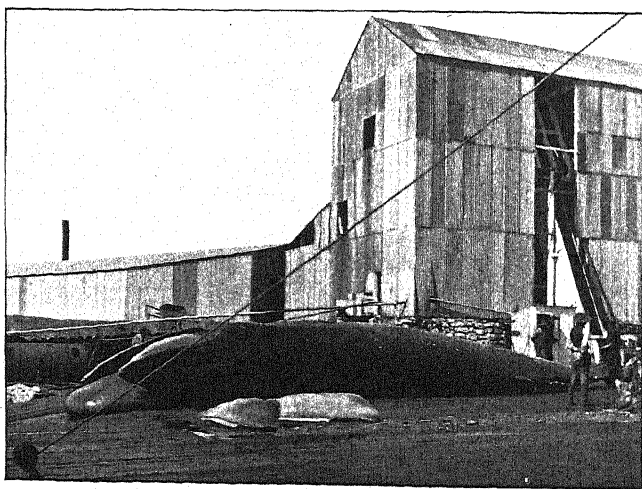
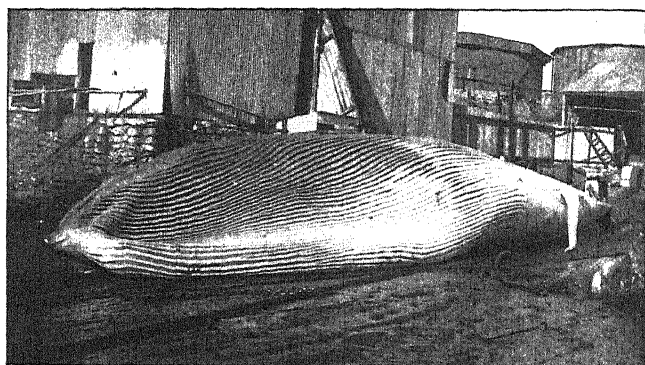




BALÆNOPTERA BRYDEI.

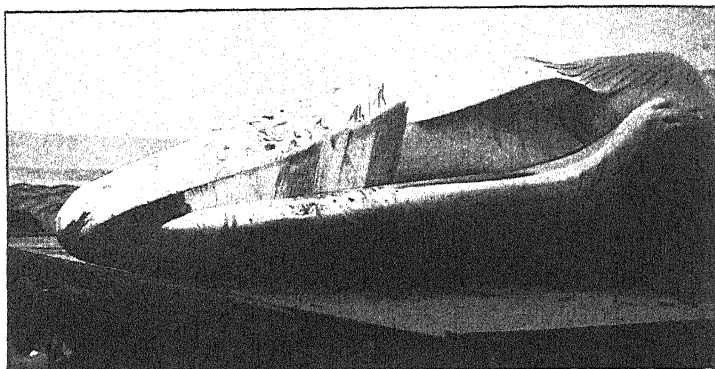




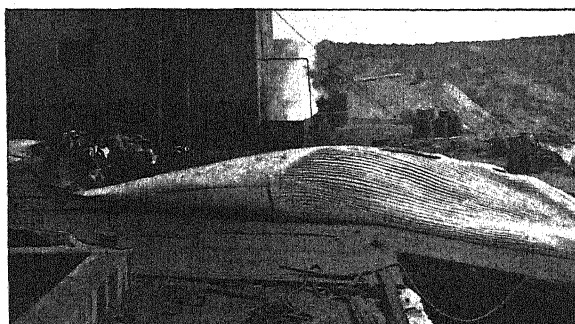


BALÆNOPTERA BRYDEI.





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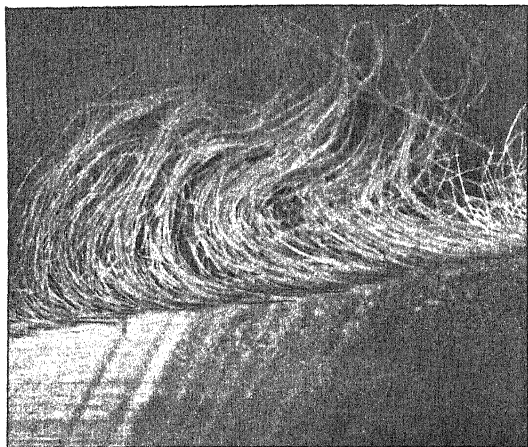


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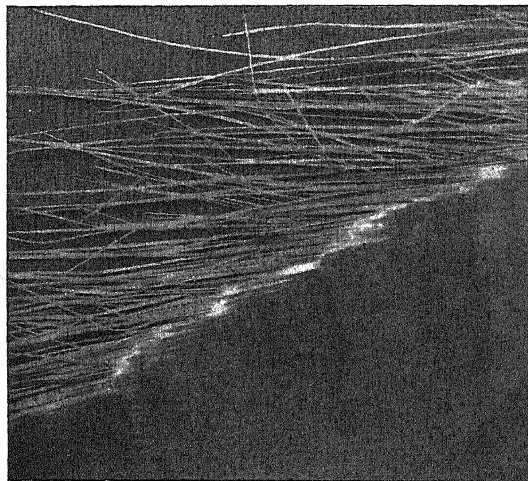
BALÆNOPTERA BRYDEI.



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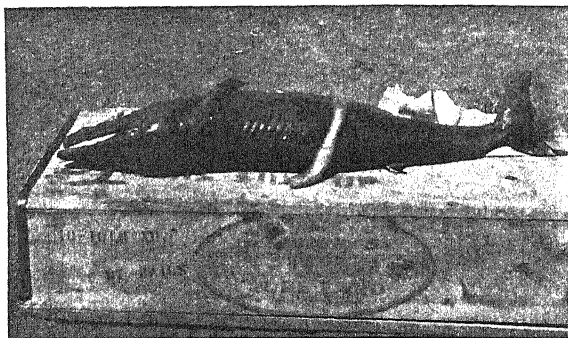
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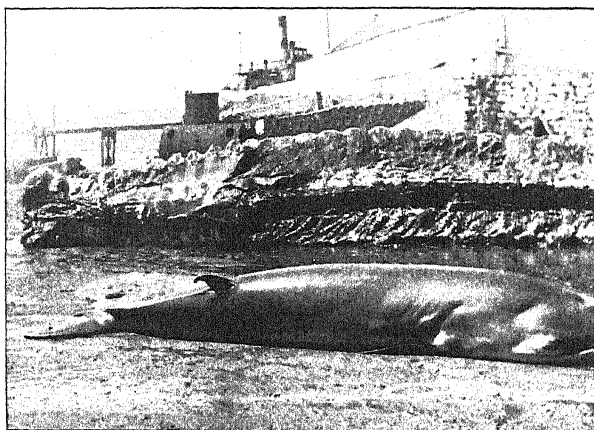
9, 11A. BALÆNOPTERA BOREALIS. 10, 11B. B. BRYDEI.



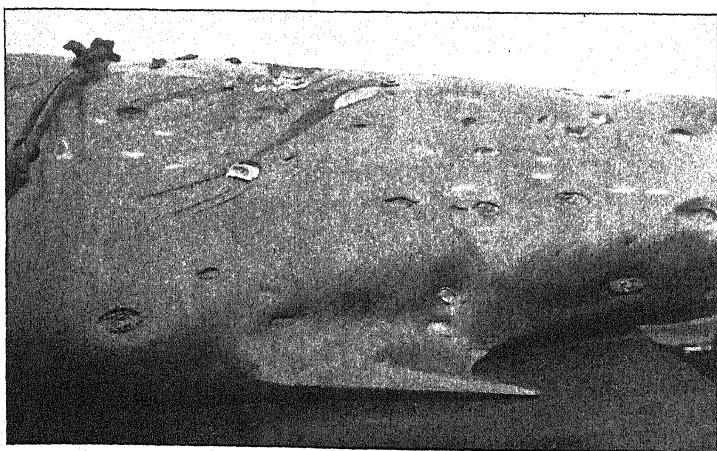
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14



BALÆNOPTERA BRYDEI.



61. On the External Characters and Biology of Bryde's Whale (*Balenoptera brydei* \*), a new Rorqual from the Coast of South Africa. By ØRJAN OLSEN, Zoological Laboratory, Christiania University †.

[Received June 27, 1913: Read November 25, 1913.]

(Plates CIX.-CXIII.‡)

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*Introductory remarks.*

Before the Norwegian whaling trade started in South Africa in 1909, opportunities for studying whales from that part of the world seldom occurred, but when at rare intervals one of the bigger whales was stranded on the S. African coast, if it was not at once eaten by sharks it was, as a rule, quickly destroyed by the warm climate and heavy sea breaking on the beach.

The country is very extensive, the communication along the sea-shore bad, and journeys difficult and expensive. If, therefore, one of the few scientists of the country received a report of a stranded whale, it was as a rule impossible for him to reach the spot before it was too late. So when we take all these difficulties into consideration it is not surprising that the bigger whales from this part of the world have remained unknown until quite recently.

Mr. W. L. Sclater has only the following to say about the genus *Balenoptera* in the standard work 'Fauna of South Africa' (1901):—"Fin-whales are not uncommon off the coast of S. Africa, but so far as I know, no specimen has ever been secured for a museum, or been examined by a competent authority." After this he gives the characteristics of the four northern fin-whales, in order to facilitate comparison with the Cape species of the same genus.

The South African whaling industry was founded by Consul Johan Bryde, from Sandefjord, Norway, who in 1909 erected the first factory in Durban and another in the following year in Saldanha Bay on the west coast.

When the Norwegian whalers returned home after having finished their first season in Saldanha Bay, they mentioned a whale which had been found outside the latter place, and which was very similar to the "seihval" (*Balenoptera borealis*).

As the "seihval" (Rudolphi's whale) had been only known

\* [I have consulted the issue of the Norwegian newspaper 'Tidens Tegn' dated November 12th, 1912, in which this name was first published by the author. Technically the species dates from the description in that Journal, but no details are given there which are not fully explained here.—EDITOR.]

† Communicated by the SECRETARY.

‡ For explanation of the Plates see pp. 1089, 1090.

until then as inhabiting the eastern parts of the North Atlantic, it was very desirable from a scientific point of view to get further information about the species from Saldanha Bay, and also about other South African whales, by studying them on the spot. Mr. Johan Bryde, who has often displayed his interest in and generosity towards science, then offered me the necessary pecuniary assistance, and thus enabled me to undertake a journey to South Africa to study the above questions and some other scientific matters there. During this expedition, which lasted nearly a year, I visited both the east and west coasts and was able to make many interesting observations.

The "seihval" from Saldanha Bay proved to be very different from Rudolphi's whale (*B. borealis*), and is described in this paper as a new species, named after Johan Bryde, to whose generosity I am so much indebted. I have also to thank Capt. Andr. Ingebrigtsen, Capt. P. J. T. Larsen, and Mr. Lars Iversen for their kind help.

#### BALÆNOPTERA BRYDEI Olsen.

'Tidens Tegn,' November 12, 1912. (A Norwegian newspaper.)

#### *Synopsis.*

The average total length is 13 and the maximum nearly 15 metres. The shape is very elongated; the greatest height 13-14 per cent. of the total length. The distance from the tip of the snout to the angle of the mouth is about 20 per cent. of the total length. The flippers are slender and pointed, 8-10.6 per cent. of the total length. The dorsal fin is small: its vertical height 2-2.4 per cent. of the total length. The distance from the tip of the snout to the anterior margin of the dorsal fin is 69-70 per cent. of the total length, occasionally shorter; the minimum is 65 per cent. The distance from notch of flukes to vent is about 27.2 per cent. of the total length; the number of ventral furrows 42-54; they extend backwards to the umbilicus, about 1.2 metres behind the tip of the flippers. The number of baleen-plates (without the anterior rudimentary baleen) 250-280; their greatest length nearly 0.50 metre. The bristles of the baleen are very thick, long and stiff, not curling; their colour is grey. The anterior baleen is as a rule more or less white; the other greyish-black. The upper side of the flipper is bluish-black, the under side grey. The colour of the body is bluish-black above, with oblong light-coloured spots; the throat and an area up to about 0.65 metre below the flippers on each side are dark bluish-grey; the other parts of the under side are white, more or less yellowish, often with a grey band across the belly in front of the umbilicus.

#### *General Characteristics and Measurements.*

*Balaenoptera brydei* is a comparatively small species, with an average total length of about 13 metres, or occasionally a little

more. The longest specimen measured by me, and one of the largest captured by the Norwegian whalers in South Africa, was a female from Durban measuring 14.95 metres. The female seems to attain a slightly larger size than the male.

During my stay at the whaling stations in Durban and at Saldanha Bay I was able to examine twelve specimens in all; and the following table gives the measurements and some other characteristics of three which showed comparatively great differences.

Measurements of *Balenoptera brydei* (in metres).

	♂. 12.9.12.		♂. 5.3.13.		♀. 15.11.12.	
		per cent		per cent		per cent
Total length .....	12.35	100	13.07	100	14.95	100
Tip of snout to anterior end of eye .....	2.41	19.5	2.40	18.3	2.9	19.4
" " angle of mouth .....	2.50	20.2	2.48	18.9	2.9	19.4
" " anterior end of dorsal fin ..	8.55	69.2	8.5	65.0	10.5	70.0
" " blowholes .....	1.85	15.0	2.05	15.6	2.36	15.6
" " flippers (anterior margin) ..	4.0	32.3	4.0	30.6	4.9	32.7
From notch of flukes to vent .....	3.38	27.3	3.56	27.2	4.5	30.1
" " " hinderside of penis or vulva .....	4.43	35.0	4.61	35.2	4.8	32.1
Length of the flippers (from axilla) .....	1.0	8.0	1.39	10.6	1.23	8.3
Greatest breadth of the flippers .....	0.33	2.6	0.36	2.7	0.40	2.6
Breadth of the flippers at base .....	...	...	0.28	2.1	0.35	2.3
Vertical height of the dorsal fin .....	0.30	2.4	0.30	2.2	0.31	2.0
Diameter of eye .....	0.10	...	0.12	...	0.10	...
Length of the eye-opening .....	0.75	...	...	...	...	...
Length of the blowholes .....	...	...	0.40	...	0.32	...
Distance between the anterior ends of the blowholes .....	...	...	0.02	...	0.04	...
Distance between the posterior ends of the blowholes .....	...	...	0.22	...	0.18	...
Length of the anus .....	0.10	...	0.12	...	0.08	...
Length of the penis or vulva .....	1.37	...	1.06	...	0.18	...
Diameter of penis at base .....	0.20	...	...	...	...	...
Number of baleen-plates in each jaw (the rudimentary baleen not included) .....	ca. 260	...	ca. 250	...	ca. 280	...
Greatest length of the baleen-plates (with- out bristles) .....	0.38	...	0.32	...	0.49	...
Greatest breadth of the longest baleen (at the base) .....	0.18	...	0.14	...	0.23	...
Greatest thickness of the longest baleen ..	0.05	...	...	...	ca. 0.03	...
Length of the anterior (rudimentary) baleen .....	0.15	...	0.12	...	...	...
Length of the longest bristles (on the longest baleen) .....	0.20	...	0.14	...	0.12	...
Number of furrows between the flippers ..	48	...	54	...	54	...
Height of the body at the flippers .....	ca. 1.8	14.7	...	...	...	...
Distance between the flippers on the ventral side .....	...	...	2.0	...	...	...

The shape of *B. brydei*, as of the other species of the genus *Balenoptera*, varies somewhat, but as a rule it is remarkably elongated (Pl. CLX.), often even more so than in the Fin-whale

(*B. physalus*). The greatest height of the body (at the anterior end of the flippers) is usually about 14 per cent. of the total length, occasionally less, and only in a single case (a male of Saldanha Bay, 12.9.12) is it as much as 14.7 per cent. The greatest breadth is almost the same as the height, or a little less. In five specimens measured by me in Saldanha Bay the proportion of the greatest breadth (at the flippers) compared with the total length was as follows:—12.8, 12.9, 14, 14.2 per cent., which gives an average breadth of 13.4 per cent. In a single case—that of a very thin male—the breadth was only 11.8 per cent. The body is therefore of a far less powerful build than in *B. borealis* and *B. acutorostrata*, and resembles more that of the Fin-whale (*B. physalus*). The hinder part of the body (from the genital opening to the tail) is comparatively less compressed than in *B. borealis*, but decreases gradually and slowly towards the rear up to the root of the tail-flukes. The caudal part forms a thin ridge above and below, which is at its sharpest along the dorsal line (Pl. CXI. fig. 7). In order to facilitate the comparison between *B. brydei* and the other species of the genus *Balænoptera*, I have added a table showing the most remarkable differences. I have not considered it necessary to mention the Blue whale (*B. musculus*), as its size, dorsal fin, colour, and many other characteristics make any confusion with *B. brydei* impossible.

TABLE

showing the most notable differences between *Balænoptera brydei* and the other species of the same genus (except the Blue whale).

	<i>B. acuto- rostrata.</i>	<i>B. borealis.</i>	<i>B. brydei.</i>	<i>B. physalus.</i>
Total length (maximum) .....	10.3 m.	16.3 m.	15 m.	24 m.

## Per cent. of total length.

From tip of snout to blowhole .....	13.5	15.1	15.3	...
" " " angle of mouth .....	13-17	17.8	19.4-20.2	ca. 20
" " " flippers .....	...	29.8	30.6-32.7	33
" " " dorsal fin .....	...	61-68	65-70	69-73
Height of body at the flippers .....	20	18	14	...
Height of the dorsal fin .....	4-5.6	3.3-4.7	2-2.4	...
Length of the flippers (from axilla) .....	...	8.7-9.3	8-10.6	9.9-11.3

Greatest breadth of the flippers com- pared to their length .....	...	{ as 1 to 3.5 or 3.6	as 1 to 2.2	...
Number of ventral furrows .....	...	...	42-54	60-100
Number of baleen-plates (without the rudimentary baleen) .....	...	320-340	250-280	350-400
Greatest length of baleen in adult specimens (without bristles) .....	0.20 m.	0.72 m.	0.49 m.	0.90 m.

*B. borealis.**B. brydei.*

Distance from notch of flukes to anus.....	31·6 per cent. (of the total length).	27·2 per cent. (of the total length).
Ventral furrows.....	Extend to the middle of the belly one foot behind tip of flippers.	Extend to the umbilicus, 3·5 feet behind tip of flippers.
Colour.....	The throat always white: the underside behind anus bluish black, like the back.	The throat dark bluish-grey: the underside behind anus <i>white</i> , sometimes yellowish or whitish grey.
Bristles of baleen .....	Unusually fine, short, curling and wool-like, white.	Very thick, long and stiff, not curling, colour grey.
Food and habits .....	Always small crustaceans, chiefly Calanidæ. Never takes fish.	Fish. When it occasionally takes crustaceans, they are Euphausiidae, like the Blue whale.
	Blows as a rule only once or twice during each visit to the surface.	Blows 5-6 times during each visit to the surface (like the Fin- and Blue whales).
	Migratory.	Stationary.

The distance from the tip of the snout to the angle of the mouth is, as we have seen, 19·4-20·2 per cent. of the total length, about the same as on the fin-whale, whereas in Rudolphi's whale it is only about 17·8 per cent. (according to R. Collett). The tips of the snout and of the lower jaw are also far more acute than in *B. borealis*, more resembling those of *B. physalus*.

The *flippers* are very slender and pointed, generally comparatively short, but varying in length from 8-10·6 per cent. of the total length, and they are thus sometimes remarkably longer than has ever been observed in *B. borealis*. Their greatest breadth (at the middle) compared to the length is as 1 to 2·2. They differ in this respect very much from those of *B. borealis*, where the proportions are as 1 to 3·5 or 3·6, and they are more like the flippers of *B. physalus*. There is often a cut of about an inch in breadth and depth in their posterior margin, near the axilla.

The *dorsal fin* is of very moderate size, and its vertical height only about 2·2-2·4 per cent. of the total length. It is thus smaller than is usual in the fin-whale, and very different from the large dorsal of *B. borealis* and *B. acutorostrata*. Its length from the anterior to the posterior end is only slightly greater than its vertical height. The front margin is convex, with a slightly curved apex, and the hinder margin is deeply concave and often has a small cut in it near the base. The point of the fin is very thin and sharp. The dorsal fin is placed noticeably further back than is the case in Rudolphi's whale—often where it would be on the fin-whale. In twelve adult specimens examined by me the distance from the tip of the snout to the anterior end of the dorsal fin was in most cases 69-70 per cent. of the total length, and in one instance only 65 per cent. In *B. borealis* the dorsal

is usually placed anterior to the beginning of the last third of the body (according to R. Collett).

The *tail-flukes* are broad and comparatively somewhat shorter than in *B. borealis*. The length of each fluke is from 10–11 per cent. of the total length, or about the same as in the fin-whale. In a male specimen, of which the total length was 13·07 metres, their thickness at the base was about 0·20 metre and 0·12–0·14 metre halfway between the base and the tip.

On each side of the tail, above and below, there is a thin ridge which gradually becomes lower towards the rear, and disappears between the flukes, about 0·10 metre from the end of the body.

The *eyes* are comparatively larger than in the fin-whale, and placed just above the angle of the mouth, in the same place as in the fin-whale, but further back than in *B. borealis*.

The distance from the tip of the snout to the *blowholes* is about 15·3 per cent. of the total length. In adult specimens the length of the blowholes is from 0·32–0·40 metre. They are placed on a broad ridge on the head in two long furrows, which converge very much towards the front. Between them there is a shorter central furrow.

The *ventral furrows* run along the whole length of the lower jaw and extend to the umbilicus, about 1·2 metres behind the tip of the flippers (as in the fin- and blue whales). In *B. borealis* they end about 0·30 metre beyond the tip of the flippers (R. Collett). Above the long furrows there are 5–8 shorter ones with a length of 0·30–0·60 metre, and these terminate in the axilla. In front of the flippers there are also a few short furrows which extend forward into the angle of the mouth. On the belly, in the area below the angle of the mouth, some shorter furrows are as a rule wedged in amongst the others. Just in front of the umbilicus, where the long furrows terminate, a number of quite short furrows are also to be seen. The number of long furrows varies from 42–54.

The *anus* is noticeably further to the rear than in *B. borealis*, and the distance from the anus to the notch of the flukes is as a rule about 27·2 per cent. of the total length.

The *penis* is rather big and with the *vulva* is placed in a generally dark-coloured furrow 1–1·5 metres long, about two-thirds of which run anterior to the genital opening, and about one-third behind.

A varying number of whitish-grey oblong spots, about 7–8 cms. in length and about 3 cms. in breadth, are distributed over the whole body. Along the centre of their long axis there runs usually a dark line, from which fine radii of similar lines run in all directions. These patches probably show places once attacked by parasites. In addition to these whitish spots a number of fresh wounds, with a length of as much as 10 cms. and 3–4 cms. deep, can be seen in most cases. They are marks caused by parasites—generally a *Pennella*.

The majority of specimens of Bryde's whale are very thin, and their stratum of fat has an average thickness of only 4-5 cms. In a single instance—that of an old and probably diseased female specimen from Durban—the thickness was only about 3.5 cms. Some big specimens, especially females with foetus, may be quite fat and their stratum of fat may attain a thickness of as much as 7 cms., at any rate on the dorsal side. Specimens as fat as this may yield 15 or occasionally nearly 20 barrels of oil, while the common yield of this species is only 6-8 barrels.

### *Baleen.*

During my stay in S. Africa I was able to examine the baleen of twelve adult specimens, and also a large quantity of whale-bone which lay heaped up outside Mr. Bryde's whaling station in Saldanha Bay.

The *baleen* of *B. brydei* is very distinctive of this species, and compared with the size of the whale, very small (see Pl. CXII. fig. 11 B). The longest baleen-plates measured by me, and from a female specimen of nearly 15 metres in length, were only 0.49 metre long (the bristles not included), while baleen from a Rudolphi's whale of the same size attains a length of about 0.70 metre. The baleen differs remarkably in shape from that of *B. borealis*; whereas the baleen-plates of *B. borealis* are very long and slender, those of *B. brydei* are comparatively very broad and curve inwards along the inner margin. The comparative proportions of the breadth of the largest baleen-plates at their base and their length were in four specimens of *B. brydei*:—43, 43.1, 46.9, and 47 per cent., which gives an average of 45 per cent. In *B. borealis* the same proportion is about 27.2 per cent. (see Pl. CXII. fig. 11 A). The baleen of *B. brydei* seems also to be comparatively somewhat thicker and more strongly built than in *B. borealis*. The number of plates in twelve specimens examined by me was, as a rule, about 260 in each jaw, though the number varied between 250 and 280. But if the rudimentary plates are included, the number may be about 350. The number of baleen-plates in *B. brydei* is remarkably small; for Rudolphi's whale the number (without the rudimentary baleen) is from 320 to 340, and in the fin-whale from 360 to 400.

The rudimentary plates along the tip of the upper jaw are not compressed, and attain a length of 0.10-0.15 metre; they are numerous and difficult to count. The first compressed plate is seen about 0.25-0.30 metre behind the tip of the snout. There is also some rudimentary baleen above the angle of the mouth.

The *bristles* (Pl. CXII. fig. 10) are longer than in *B. borealis* and thick and stiff, not curling, and on the whole of very strong construction—even comparatively stronger than in the fin-whale. Their average thickness is about 1 mm.; a little more at the distal end of the baleen, and perhaps a little less at the base.

*B. brydei* differs very much in this respect from *B. borealis*, and it would hardly be possible with its imperfect straining apparatus to keep back such small crustaceans as the Calanidae, which form the chief food of *B. borealis*.

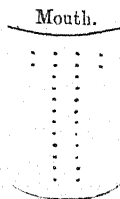
The colour of the baleen in the anterior part of the jaws, and about 0.70 metre backwards from the tip of the snout, is as a rule more or less white, sometimes perfectly white, but more frequently with grey stripes; further back it is greyish black, and after death perfectly black. The bristles are grey, whitish grey or yellowish in the anterior part of the mouth. The colour of the baleen is on the whole rather similar to that of the fin-whale, and the whalers told me that in some cases they had even seen the white colour asymmetrically placed, as in the fin-whale. The baleen might in one jaw be white over a comparatively large area, and in the other jaw fairly uniformly dark-coloured. A male caught in Saldanha Bay, March 5, 1913, had only dark-coloured baleen. In this respect too *B. brydei* differs considerably from *B. borealis*, in which the whalebone is only rarely white-mottled and as a rule uniformly black with white bristles.

In connection with the description of the whalebone, it is worth mentioning that some time after I had given the first preliminary report on *B. brydei* in a Norwegian newspaper, Mr. Bryde wrote to me saying that he could now understand the reason for a law-suit in which he had been implicated some time before. He had sold a consignment of baleen from his factories in S. Africa which his agents there considered to be "seihval" (*B. borealis*). The buyers, however, complained and returned the whalebone, saying that it was not from *B. borealis* but from another species of whale. The result was a law-suit in which the authorities who examined the whalebone gave judgment in favour of the buyers, and Mr. Bryde was obliged to pay a large fine and take back the whole consignment.

The Norwegian whalers in South Africa said too that this whale (*B. brydei*) was not the proper "seihval"; but as it was most like the "seihval" in size and colour, they generally called it that.

#### *Hairy covering.*

In all the specimens examined by me (except in the case of an old and probably diseased female specimen from Durban, on which I could see no hairs at all), I found two rows of hairs on the tip of the lower jaw, with twelve hairs in each row, thus:





The distance between these rows in adult specimens was about 18 mm., or a little more than between the successive hairs in each row. Outside the upper end of these rows were two other hairs on each side, placed at the same distance from the long rows as between the rows themselves. I noticed no hairs on the upper jaw.

The number of hairs is thus 28 in all. On two fetuses, with a length of 3.78 and 0.935 metres, the hairy covering was as well developed as in adult specimens. The length of the hairs was from 5-10 mm.

### *Colour.*

The upper side of the body—above the flippers—is bluish black, and in colour much resembles the fin-whale. After death the colour on this part becomes almost entirely black. On the sides of the body the colour becomes gradually lighter, and there is no sharply defined border between the dark colour of the upper side and the white belly. The flippers are of the same colour as the back above, or sometimes darker; below they are grey, occasionally whitish grey. The under side of the head, and a band extending to about 0.70 metre below the flippers and backwards to their tip are bluish grey. The centre of the belly is a more or less yellowish white. In the dark area below the flippers some isolated white spots may sometimes be seen; similar white patches are occasionally distributed along the centre of the under side of the lower jaw, and more rarely a small white line runs out from the white area on the belly to within one metre or less behind the tip of the lower jaw. On the border between the dark colour of the throat and the white belly there are often a number of bluish grey patches or stripes, and these are more thickly sprinkled towards the front, and then gradually form a more uniform dark colour in front of the angle of the mouth. Between the tip of the flippers and the umbilicus—at the posterior end of the long furrows—the white colour of the under side is generally interrupted by a bluish grey belt running across the stomach. This belt, which has a breadth varying between 0.70 and 1.5 metres, is often formed by a large number of smaller and larger patches or stripes, not of uniform colour; in other cases it is very little developed.

Considerable variations occur in the breadth, size, and shape of the white area on the belly.

From the genital opening to the tip of the tail-flukes the whole under side is dirty white, sometimes yellowish or whitish grey. This white area begins above the genital opening at the middle line of the sides of the body, and in some specimens is further back and becomes gradually narrower.

From the tip of the upper jaw, near the roots of the baleen, sometimes a white stripe runs backwards, and the length of this is about 0.5 metre and the breadth 5-7 cms.

The dark patches which are sometimes found on the under side are generally situated in the long furrows, or in the furrow at the genital opening.

*Occurrence and Capture.*

*Balenoptera brydei* seems to be common everywhere along the south coast of Africa. It is especially so in Saldanha Bay, though also in Mossel Bay and near the Cape of Good Hope this species is captured in rather large numbers, and is often observed from whaling steamers going along the S. African coast.

In Durban *B. brydei* is comparatively rare, but is occasionally to be seen at all seasons of the year. The total number captured from three whaling stations on the Natal Bluff during the season 1912 was only sixteen, of which one (captured early in November) was only about 8 metres long, and not fully developed. In 1911 six specimens were captured from Mr. Bryde's station in Durban. Of these two were taken on June 5th, one on the 14th, and one on the 15th of the same month, one on October 10th, and one on November 7th. In 1912 the following were caught from the same station:—one on June 4th, one on July 18th, one on Aug. 19th, and one on Nov. 15th. Some specimens were seen but not pursued because, as the whalers told me, they were very shy and difficult to catch, and at the same time their value was comparatively small. At Mr. Bryde's whaling station near Inhambane, Portuguese E. Africa (23° 30' S. l.), *B. brydei* was very seldom seen, and only a single specimen of it was captured. Further to the north at Bazaruto Is. (21° 45' S. l.), where the floating factory "Mangoro" was stationed for two months, *B. brydei* was never seen. Bryde's whale therefore seems to be a southern species, avoiding the warm waters of the tropics, and it is therefore rare on the east coast where the hot Mozambique current runs southward.

Almost all the specimens of *B. brydei* captured in Saldanha Bay (33° S. l.), were found between this bay and Capetown, and the whalers told me that this species was much more rarely seen north of Saldanha. This fact is quite in accordance with the experiences of Mr. Green, the manager of Storm Bull's whaling station in Walfisch Bay. He considered the "seihval" to be very rare along the coast of German S.W. Africa, and he had not observed this species at all in Walfisch Bay.

I was somewhat surprised therefore when Capt. Andr. Ingebrigtsen, who had been stationed with a floating factory at Porto Alexandre, Benguela (15° 45' S. l.) for a couple of years, told me that he had observed rather a large number of "seihval" there. The same statement was made by Capt. L. Fredriksen, who had seen many specimens of this whale outside Lobito Bay, and single ones as far north as 7° S. l. But when we remember that a cold antarctic current runs along the west coast of Africa

far to the north, it is not so surprising that *B. brydei* may be able to live outside the tropical parts of the coast. The conditions of existence, however, for this species cannot be very good there, because the 3 or 4 specimens captured (during nearly three years) outside Pt. Alexandre were all unusually thin and did not yield more than 2-3 barrels of oil, or sometimes even less. All the specimens seen at this place were in very bad condition, with numerous wounds from parasites over the whole body, and so thin that the whalers did not care to pursue them. They were never seen accompanied by young ones outside Pt. Alexandre, and they were all lying almost motionless and did not make any efforts to escape from the steamer. Unfortunately not a single specimen has been examined from this part of the African coast, and very few were captured, because the whalers always preferred to take the more valuable "humpback" whales, which were to be found in the same locality. It has therefore not yet been proved whether the "seihval" from the coast of tropical W. Africa really is *Balaenoptera brydei*.

Capt. Andr. Ingebrigtsen also told me that the "seihval" outside Pt. Alexandre appeared in these waters every year about the middle of June and disappeared again about September or October.

If this whale follows the same route as the "humpback" generally does—along the coast—we might expect to see migrating specimens pass Saldanha Bay, and to find a greater number of them there in the spring, October-November, but this is not the case. It is probable therefore that they choose another route, perhaps further out to sea, where the current is stronger and the water cooler.

It is not impossible that some of the "sei"-whales from Portuguese W. Africa may have been Rudolphi's whale (*B. borealis*), a typical specimen of which was captured outside Saldanha Bay in November 1912. This is the first S. African specimen of *B. borealis* which has been reported further south than off Cape Blanco (20° 45' N. l.). It was easily recognized as the proper "seihval" by the Norwegian whalers; and Capt. P. J. Larsen kindly presented me with a quantity of the baleen, which was quite distinctive of *B. borealis* (Pl. XCII. fig. 9).

As I have mentioned above, Saldanha Bay is the locality where the greatest number of *B. brydei* are captured. The whaling trade was started there in 1910, and only twenty-four specimens of the "seihval" were captured in the first year, and all of them in the spring. The first three specimens were caught on March 9th and 29th, and on April 1st. Five were captured from the 20th to the 30th of April, four from the 1st to the 10th of May, six from the 10th to the 20th of May, and six from the 20th to the 30th of May. After that time the "humpback" was found at this spot in large numbers.

The following list shows the number of "seihval" captured at

Mr. Bryde's station in Saldanha Bay during the season of 1911 (with two whaling steamers), and in the season of 1912 (with three whaling steamers).

	1911.	1912.
March 20-30 .....	—	7
April 1-10 .....	—	8
April 10-20 .....	—	37
April 20-30.....	—	22
May 1-10 .....	—	25
May 10-20 .....	6	5
May 20-30 .....	8	2
June 1-10 .....	2	1
June 10-20 .....	5	9
June 20-30 .....	3	3
July 1-10 .....	1	2
July 10-20 .....	2	—
July 20-30 .....	2	9
Aug. 1-10 .....	2	9
Aug. 10-20 .....	2	7
Aug. 20-30 .....	2	3
Sept. 1-10 .....	—	1
Sept. 10-20.....	—	1
Sept. 20-30.....	—	1
Oct. 1-10 .....	1	—
Oct. 10-20 .....	—	1
Oct. 20-30 .....	—	2
Nov. 1-10 .....	—	1
Nov. 10-20 .....	1	6
Nov. 20-30 .....	3	3
Dec. 1-10 .....	2	3
Dec. 10-20 .....	—	1
Total.....	42	169

The table shows that the majority of *B. brydei* are captured in the autumn (April and May), and at this time this species also seems to be the most numerous outside Saldanha Bay, as well as Durban. But we see also that it is captured in greater or less numbers during the whole season, and it is seen outside Saldanha Bay all the year round.

The difference between the real number of *B. brydei* in the autumn and at other times of the year is in fact not so great as the capture seems to indicate, because the whalers always prefer to take the more valuable "humpback" whale when this species appears on the spot in May. In 1912 an unusually small number of "humpbacks" was seen, and the trade depended on the "seihval" to a greater extent than before.

In 1913 the first specimen was caught on March 5, and from

that date until I left Saldanha Bay a fortnight later, the total catch of *B. brydei* consisted of eleven specimens. Almost all of these specimens were found unusually far (40–70 miles) from the sea-shore, surrounded by large numbers of crustaceans, Euphausiidae. As a rule the whales are to be found quite close to the coast, and it is probably the richness of crustaceans further out to sea that has tempted them to go out there. It is worth mentioning that these crustaceans were Euphausiidae, which the Blue whale prefers, and not Calanidae, the chief food of Rudolphi's whale.

#### Food.

The food of *B. brydei* consists chiefly of fish, apparently usually a variety of herring which is often found in large quantities (many hectolitres) in its stomach. This, for instance, was the case with a male examined by me in Saldanha Bay on September 12th, 1912. It sometimes takes a species of mackerel one foot or more in length, and in Durban more than a hectolitre of this fish has been found in its stomach.

*B. brydei* is very voracious on the whole—more so than any other species of its genus. As an illustration of this, Capt. L. Fredriksen told me that he had many times seen it hunting among large crowds of small sharks, and that he had found sharks of a length of more than two feet in its stomach. A case from Saldanha Bay which was related by Captain Christoffersen, and mentioned by many others, was most astonishing: they had found there no less than 15 large penguins (*Spheniscus demersus*) and "malagass" (*Sula capensis*) in its stomach. These birds, the moment the whale reached the surface of the water, had probably dived down into its open mouth endeavouring to catch fish in that abundant hunting-ground, and had thus themselves been involuntarily captured by the whale. In similar cases observed among *B. borealis*, the birds have always been spat out of the mouth again, and it seems hardly possible that such large birds as those mentioned could be swallowed by this species at all.

*B. brydei* is not dependent for food on the occurrence of crustaceans in the sea and so does not migrate, but is generally seen very close to the coast pursuing fish.

Like the fin-whale, *B. brydei* occasionally takes crustaceans and then of a larger kind, the Euphausiidae.

#### Biology, etc.

In its biology *B. brydei* is most like *B. acutorostrata* and *B. physalus*, and when the Norwegian whalers started their trade in South Africa they were doubtful as to whether they should consider this species to be a fin-whale or a "sei"-whale (*B. borealis*). In Durban many of them preferred to call it a

"sildehval" (herring whale), because it hunted herrings. But as the colour and size were most like that of the "seihval," they generally called it so, although they knew that it was not the proper "seihval."

In Saldanha Bay, where the largest numbers were captured, it was often called "bastard" or "seihval bastard," and considered to be a hybrid between the fin-whale and the "seihval," because it had the baleen of the first species, but some other characteristics of the latter. Besides this "bastard," the whalers in Saldanha Bay told me about another variety of "seihval" with exceedingly dark-coloured baleen. It was of somewhat smaller size than the "bastard," quicker in its movements, dived deeper down in the sea, and was more difficult to catch. It was seen in approximately the same numbers all the year round, and in the same localities as the "bastard," but seemed to occur in greater numbers northward of Saldanha Bay than the latter, as proved by Capt. Christoffersen, who had captured it many times outside Paternoster Bay. When the whaling steamers went to Capetown for coaling, these two varieties were often seen in greater numbers together, and the whalers picked out the "bastard" as more valuable and easier to catch.

Unfortunately, during my stay at Saldanha Bay, not a single specimen of this smaller variety was captured, and it is therefore difficult to say anything about them, but I consider it probable that they are only younger specimens of *B. brydei*.

*B. brydei* is as a rule to be found very close to the coast, generally in large numbers, and it is comparatively rarely found further out to sea. The whalers in Saldanha Bay often found it pursuing fish only a few hundred yards from the beach between Robben or Dassen Island and the continent. In Durban it was also seen close to the coast (occasionally as far out as 15 miles from shore), but never in company with the small "minkehval" (probably *B. acutorostrata*, or a subspecies closely akin) nor with other whales. As mentioned above it has occasionally been found 60-70 miles from the coast feeding upon Euphausiidae.

It is most like the fin-whale in its manner of swimming, and can easily be distinguished from the small "minkehval." When coming to the surface to breathe, it may be seen under the water for some time before it appears on the surface. During each such visit it blows four or five times (like the fin- and blue whales, whereas Rudolphi's whale blows only once or twice) before diving down into deep water again. Between these four or five blows it does not go too deep down to be seen from the ship and followed. It blows far more strongly than does *B. acutorostrata*, and its breath smells worse than that of the other whales. In Durban it was observed to remain for an unusually long time under water between each visit to the surface. It is not seen to take crustaceans in the same peculiar way as Rudolphi's whale (*B. borealis*). When shot it often swims

round in circles very quickly and gets the line wound round it, and is on the whole difficult to manage. Large females are less difficult to shoot than the others, as they are not so quick in their movements.

Gravid females do not seem to be followed by their males as is the case with the humpback whale. For instance, two females captured in Saldanha Bay, March 12, 1913, and with foetuses measuring 0.935 and 3.78 metres, were swimming about quite alone. Some males captured at this time were also solitary.

They are gravid at very different times, and females were found with foetuses of different sizes both in Saldanha Bay and Durban, at the same time as others were followed by young with a length of about 6-7 metres.

It may be mentioned as a curious fact that almost all the "sei"-whales captured in Saldanha Bay from March 5-13, 1913, went southwards when the whaling steamers began to hunt them.

The flesh of *B. brydei* contains less oil than does that of other species of its genus, with the exception perhaps of *B. borealis*. When fresh and served like beef-steak it tastes quite good, as I had an opportunity of proving when at Saldanha Bay.

#### *The Foetus.*

About an equal number of each sex of *B. brydei* seem to be caught. Many of the females were gravid, and, as mentioned above, with foetuses of very different sizes:—*e.g.*, in two gravid females examined by me in Saldanha Bay, March 12, 1913, the fetuses had a length of 0.935 and 3.78 metres (Pl. CXIII. figs. 12, 13). The mammae in both these specimens were very well developed, and, when they were dragged out of the water, about a half-gallon of mucus ran out of their genital openings, as has sometimes been observed shortly after the birth of the young in other whales. The largest foetus was full-grown, and fell out when the men began to remove the stratum of fat from the whale.

The following table shows some measurements of the two foetuses.

In the larger foetus the penis was placed in a furrow which ran backwards from the umbilicus for about 12 cm. The baleen had just appeared and was thick and soft, with a length of about 3 cm. The bristles had an average length of 6-8 mm. and were generally only to be seen at the base of the baleen. The anterior and posterior baleen only appeared as small ridges. The dorsal fin was bent down to the back on the left side, both the apex and the tip being curved to an unusual extent, and the hinder margin deeply concave. The tail-flukes were strongly bent together towards the median line of the body. The colour above was a uniform bluish black, and whitish grey

	Male.		Female.	
		per cent.		per cent.
Total length .....	3.78	100	0.935	100
Tip of snout to anterior end of eye .....	0.63	16.6	0.175	18.7
" " angle of mouth .....	0.70	18.5	0.166	17.7
" " anterior end of dorsal fin .....	2.47	65.3	0.655	70.0
" " blowholes .....	0.45	11.9	0.13	13.9
" " flippers (anterior margin) .....	1.2	31.7	0.30	32.0
From notch of flukes to vent .....	1.04	27.5	0.255	27.2
" " vulva or penis .....	1.35	35.7	0.273	29.1
Length of flipper .....	0.43	11.3	0.062	6.6
Greatest breadth of flipper .....	0.13	3.4	0.03	3.2
Breadth of flipper at its base .....	0.11	2.7	0.042	4.4
Vertical height of dorsal fin .....	0.13	3.4	0.026	2.7
Length of dorsal fin at its base .....	...	...	0.038	4.0
Diameter of eye .....	0.05	...	0.023	...
Length of eye-opening .....	...	...	0.015	...
Length of blowholes .....	0.10	...	0.02	...
Distance between the anterior end of blowholes .....	0.023	...	0.007	...
" " posterior end of blowholes .....	0.073	...	0.025	...
Length of anus .....	0.02	...	0.007	...
Length of penis or vulva .....	0.10	...	0.015	...
Diameter of penis at its base .....	0.03	...	...	...
Number of furrows between the flippers .....	48	...	42	...
Distance from penis to the umbilicus .....	0.33	...	...	...
From tip of lower jaw to anterior margin of umbilicus .....	...	...	0.51	54.5
Diameter of the umbilicus .....	0.09	...	0.03	...
Breadth of tail-flukes at their base .....	0.32	...	...	...
Distance between the tips of flukes .....	0.42	...	0.20	21.3
Distance from notch of flukes to tip of flukes .....	0.38	...	...	...
Breadth of the body at the flippers .....	...	...	0.12	12.8
Height of the body at base of flippers .....	...	14.4	0.17	18.1
" " at tip of flippers .....	...	13.8	...	...
" " at the eyes .....	...	13.2	...	...
" " at the dorsal fin .....	...	9.6	...	...
" " at the tail, just in front of flukes .....	...	3.6	...	...

everywhere on the under side. The change from the dark to the light colour along the sides was gradual, and no definite outline could be seen. There was a more greyish area just behind the eyes on each side.

No baleen was to be seen on the smaller fetus, and the whole body was of a homogeneous, reddish brown colour.

#### *Abnormal Specimens.*

A large female specimen with a total length of 14.95 metres, captured in Durban, November 15th, 1912, was very like the fin-whale in colour, for the flippers were white below and the colour asymmetrical as it is in the fin-whale. The lower jaw and the distal part of the upper jaw were white on the right side, while those parts on the left side were bluish black. On the right side there was also a greater number of white baleen-plates than



on the left. The furrows were bluish black in a belt across the under side of the head and backwards to the flippers, but only a comparatively small part of the throat on the left side was uniformly dark-coloured. No hairs were to be seen on the tip of the lower jaw. This specimen was unusually slender and thin and probably was very old and diseased. The stratum of fat was only about 3.5 mm. thick; and there were numerous wounds distributed over the whole body (Pl. CXIII. fig. 14). These wounds were more or less inflamed and partly filled up with mortifying fat, and in some of them a *Pennella* was found. This specimen was lying quite motionless on the surface when it was observed from the whaling steamer, and was thus very easily taken.

The whalers from Durban told me that on one occasion they had caught a whale of this species, which on the whole under side of the body was of a colour much resembling that of the blue whale (*B. musculus*); but when it was taken it proved to be a "herring" whale (*B. brydei*).

#### *Parasites.*

Parasites are comparatively rare in this species; an old female (Durban, November 15th, 1912) had, as mentioned above, distributed over the whole body a large number of oval-shaped wounds, with a length of as much as 10 cm., and a depth of 2-4 cm. (Pl. CXIII. fig. 14). Almost all of these wounds were partly filled with mortifying fat and had been caused by a large *Pennella*, specimens of which were found in some of them. A smaller number of these wounds was found on this species at Saldanha Bay, but they were very numerous in the few old and apparently diseased specimens taken at Porto Alexandre.

A species of Myxinoid sometimes makes similar wounds in Bryde's whale, but I did not obtain specimens of them because they always leave the whale when it is dragged out of the water. I do not know whether they are to be found on the whale when alive, or only after its death.

#### EXPLANATION OF THE PLATES.

##### PLATE CIX.

##### *Balenoptera brydei.*

Fig. 1. Side view of male.

2. Lower surface of male.

##### PLATE CX.

##### *Balenoptera brydei.*

Fig. 3. Male specimen, showing the dorsal side and anterior end of the body. Saldanha Bay, 12.9.12.

4. Same specimen as fig. 3, from the ventral side.

5. Female specimen, from the dorsal side. Saldanha Bay, 12.3.13.

PLATE CXI.

*Balenoptera brydei*.

- Fig. 6. Head of a large, but very thin and apparently sick, female specimen, with numerous wounds from parasites (*Pennella*). Durban, 15.11.12.  
 7. Caudal portion, with the dorsal fin, of a male specimen.  
 8. Female specimen, from the ventral side. Saldanha Bay, 12.3.13.

PLATE CXII.

- Fig. 9. Bristles of baleen from *Balenoptera borealis*, captured outside Saldanha Bay, - .11.12.  
 10. Bristles of baleen from *B. brydei*, captured outside Saldanha Bay, - .11.12.  
 11. Baleen from adult specimens of (A) *B. borealis*, and (B) *B. brydei*.

PLATE CXIII.

*Balenoptera brydei*.

- Fig. 12. Fœtus, 0.935 m. in length. Saldanha Bay, 12.3.13.  
 13. Fœtus, 3.78 m. in length. Saldanha Bay, 12.3.13.  
 14. Portion of body of same specimen as fig. 6, showing wounds from parasites (*Pennella*). Durban, 15.11.12.

## EXHIBITIONS AND NOTICES.

October 28, 1913.

Prof. E. A. MINCHIN, M.A., F.R.S., F.Z.S. Vice-President,  
 in the Chair.

THE SECRETARY read the following report on the additions that had been made to the Society's Menagerie during the months of May, June, July, August, and September, 1913 :—

### MAY.

The registered additions to the Society's Menagerie during the month of May were 268 in number. Of these, 133 were acquired by presentation, 52 by purchase, 31 were received on deposit, 13 in exchange, and 39 were born in the Gardens.

The number of departures during the same period, by death and removals, was 185.

Amongst the additions special attention may be directed to :—

2 White-bearded Gnus (*Connochates albobubatus*), from British East Africa, new to the Collection, received in exchange on May 19th.

2 Chimpanzees (*Anthropopithecus troglodytes*), 1 Anubis Baboon (*Papio anubis*), from West Africa, and several small Monkeys, presented by W. O. Danckwerts, Esq., K.C., F.Z.S., on May 2nd, 28th, and 31st.

1 Crowned Duiker (*Sylvicapra coronata*), presented by Capt. C. H. Armitage, C.M.G., D.S.O., F.Z.S., on May 4th.

1 Pöppig's Woolly Monkey (*Lagothrix pöppigi*) and 1 Ocelot (*Felis pardalis*), from Mañaos, presented by Albert Reymond, Esq., on May 28th and 20th.

2 Naked-tailed Mice (*Uromys bruynii*), new to the Collection, and 2 Slater's Cassowaries (*Casuarus sclateri*), from S. Dutch New Guinea, presented by A. F. R. Wollaston, Esq., and C. Boden Kloss, Esq., on May 31st.

2 Himalayan Yellow-backed Sun-birds (*Ethopyga seherice*) and 1 Nepalese Bullfinch (*Pyrrhula nepalensis*), from the Himalayas, new to the Collection, purchased on May 29th.

2 Swainson's Blue Jays (*Aphelocoma sordida*), from Mexico, new to the Collection, purchased on May 26th.

1 Chestnut-faced Barn-Owl (*Strix castanops*), from Tasmania, new to the Collection, purchased on May 10th.

4 Mexican Blue Herons (*Ardea herodias lessoni*) and 2 Northern Boatbills (*Cancroma zeledoni*), from Mexico, new to the Collection, received in exchange on May 28th.

1 Gentoo Penguin (*Pygosceles papua*), from the Falkland Islands, presented by the Rt. Hon. L. Vernon Harcourt, M.P., F.Z.S., on May 6th.

3 Smooth-backed Zonures (*Pseudocordylus microlepidotus*), from S. Africa, new to the Collection, deposited on May 7th.

1 East African Scorpion (*Lepreus tricolor*), from Lake Nyanza, new to the Collection, presented by C. B. Blencowe, Esq., on May 20th.

#### JUNE.

The registered additions to the Society's Menagerie during the month of June were 295 in number. Of these 144 were acquired by presentation, 35 by purchase, 56 were received on deposit, 15 in exchange, and 45 were born in the Gardens.

The number of departures during the same period, by death and removals, was 189.

Amongst the additions special attention may be directed to:—

1 Pudu Deer (*Pudu pudu*), from Chili, and 2 Patagonian Cavies (*Dolichotis magellanicus*), from Patagonia, presented by Albert Pam, Esq., F.Z.S., on June 2nd.

3 Pumas (*Felis concolor*), born in the Menagerie on June 13th.

2 Canadian Beavers (*Castor canadensis*), from Canada, received in exchange on June 5th.

1 Savanna Sparrow (*Passerculus savanna*), from North-East America, new to the Collection, purchased on June 18th.

1 Ceylon Mynah (*Acridotheres melanosternus*), new to the Collection, presented by Dr. P. H. Bahr, F.Z.S., on June 29th.

1 Golden-fronted Woodpecker (*Melanerpes flavifrons*), from Brazil, new to the Collection, purchased on June 5th.

1 Condor (*Sarcorhamphus gryphus*), from Chili, presented by Albert Pam, Esq., F.Z.S., on June 2nd.

2 Crested Screamers (*Chauna cristata*), bred in the Menagerie on June 19th.

2 Sun Bitterns (*Eurypyga helias*), from South America, purchased on June 16th.

1 Kagu (*Rhinocetus jubatus*), from New Caledonia, presented by the Marquess of Tavistock, F.Z.S., on June 27th.

2 Spiny-tailed Skinks (*Egernia depressa*), from Australia, new to the Collection, purchased on June 10th.

A collection of Snakes from Sierra Leone including 3 Sooty Snakes (*Boodon fuliginosus*), new to the Collection, presented by Guy Aylmer, Esq., F.Z.S., on June 18th.

A collection of Snakes from India including 1 Forsten's Tree-Snake (*Dipsas forstenii*), new to the Collection, received in exchange on June 2nd.

2 Gopher Frogs (*Rana capito*), from North America, new to the Collection, received in exchange on June 2nd.

#### JULY.

The registered additions to the Society's Menagerie during the month of July were 279 in number. Of these 119 were acquired by presentation, 46 by purchase, 21 were received on deposit, 37 in exchange, and 56 were born in the Gardens.

The number of departures during the same period, by death and removals, was 250.

Among the additions special attention may be directed to:—

1 Orang-Utan (*Simia satyrus*), from Borneo, presented by Marcus S. Abrahams, Esq., F.Z.S., on July 24th.

1 Small-clawed Otter (*Lutra leptonyx*), from India, presented by H. R. Taylor, Esq., F.Z.S., on July 25th.

1 Long-tailed Mouse (*Orizomys longicaudata*), 2 Elegant Opossums (*Marmosa elegans*), from Valparaiso, new to the Collection, presented by Walter Goodfellow, Esq., F.Z.S., on July 8th.

4 Capybaras (*Hydrochaerus hydrochaerus*), from Fray Bentos, Uruguay, presented by the Liebig's Extract of Meat Co., Ltd., on July 5th.

1 Gryshok (*Nototragus melanotis*), from Constantia, Cape Colony, presented by W. Lester, Esq., on July 29th.

2 Australian Flower-peckers (*Dicaeum hirundinaceum*), from Australia, new to the Collection, presented by G. A. Heumann, Esq., on July 5th.

1 Shoebill (*Baleniceps rex*), from the Sudan, presented by Lt.-Gen. Sir Francis R. Wingate, G.C.V.O., K.C.M.G., K.C.B., D.S.O., H.M.Z.S., on July 15th.

3 Seed-Snipe (*Thinocorys rumicivorus*), from Chili, new to the Collection, received in exchange on July 24th.

2 Spinose Fence-Lizards (*Sceloporus spinosus*), 1 Graham's Snake (*Zamenis grahami*), from N. America, new to the Collection, purchased on July 22nd.

1 Bird-eating Spider (*Citharoscelsus kochii*) ♀, 1 Bird-eating Spider (*Paraphysa manicata*) ♂, from Valparaiso, new to the Collection, presented by Walter Goodfellow, Esq., F.Z.S., on July 8th.

A Collection of Millipedes (*Archispirostreptus nitidus*), from Trinidad, new to the Collection, purchased on July 11th.

#### AUGUST.

The registered additions to the Society's Menagerie during the month of August were 201 in number. Of these 122 were acquired by presentation, 15 by purchase, 14 were received on deposit, 7 in exchange, and 43 were born in the Gardens.

The number of departures during the same period, by death and removals, was 231.

Among the additions special attention may be directed to:—

1 Fettered Cat (*Felis ocreata*) and 1 Cheetah (*Cynaelurus jubatus*), presented by Dr. R. E. Drake-Brockman, F.Z.S., 1 Caracal (*Felis caracal*) and 1 Cheetah (*Cynaelurus jubatus*), presented by Capt. J. L. Berne, and 2 Cheetahs (*Cynaelurus jubatus*), presented by Arnold Hodson, Esq., from Berbera, on August 8th.

2 Indian Gazelles (*Gazella bennetti*), from Karachi, presented by A. C. Cooke, F.Z.S., on August 11th.

1 Barred Warbler (*Sylvia nisoria*), from Europe, new to the Collection, presented by R. Pearce Page, Esq., F.Z.S., on August 5th.

6 West-African Quail-Finches (*Ortygospiza atricollis*), from Gambia, new to the Collection, presented by Dr. E. Hopkinson, D.S.O., F.Z.S., on August 1st.

1 Spot-billed Toucanet (*Selenidera maculirostris*), bred in the Menagerie on August 11th.

2 Bornean Fireback Pheasants (*Lophura nobilis*), bred in the Menagerie on August 17th.

A collection of rare Reptiles from Sierra Leone, including a Black-collared Cobra (*Naja nigricollis*), a Blanding's Snake (*Dipsadomorphus blandingii*), and 3 Green Night Snakes (*Dipsadoboa unicolor*), all new to the Collection, presented by Guy Aylmer, Esq., F.Z.S., on August 2nd.

1 Hamadryad (*Naja bungarus*), from India, received in exchange on August 1st.

6 Pigmy Rattlesnakes (*Sistrurus miliarius*), born in the Menagerie on August 19th.

4 Müller's Xenopus (*Xenopus mülleri*), from West Africa, new to the Collection, purchased on August 7th.

1 Electric Cat-Fish (*Malapterurus electricus*), from Tropical Africa, new to the Collection, purchased on August 28th.

1 Scorpion (*Buthus hottentotta*), from Sierra Leone, new to the Collection, presented by Guy Aylmer, Esq., F.Z.S., on August 2nd.

## SEPTEMBER.

The registered additions to the Society's Menagerie during the month of September were 200 in number. Of these 109 were acquired by presentation, 21 by purchase, 7 were received on deposit, 26 in exchange, and 37 were born in the Gardens.

The number of departures during the same period, by death and removals, was 177.

Amongst the additions special attention may be directed to:—

10 Mouflon (*Ovis musimon*), from Sardinia, presented by H.G. The Duke of Bedford, K.G., F.R.S., Pres.Z.S., on September 16th.

1 Tigrid Cat (*Felis tigrina*) and 1 Three-toed Sloth (*Bradypus tridactylus*), from Colombia, presented by W. D. McDougall, Esq., on September 15th.

2 Variegated Agoutis (*Dasyprocta variegata*), 4 Woolly Opossums (*Philander laniger*), and 1 Sooty Amphibena (*Amphibena fuliginosa*), from Colombia, presented by Dr. H. G. F. Spurrell, F.Z.S., on September 13th.

1 Azara's Opossum (*Didelphys azarae*), 1 Burmeister's Cariama (*Cariama burmeisteri*), and 1 Western Boa (*Boa occidentalis*), from Cordova, presented by Wilfred A. Smithers, Esq., C.M.Z.S., on September 16th.

2 Abyssinian Weavers (*Cinnamopteryx rubiginosa*), new to the Collection, received in exchange on September 7th.

1 Finch-like Cow-bird (*Molothrus fringillarius*), from Eastern Brazil, new to the Collection, presented by the Marquess of Tavistock, F.Z.S., on September 24th.

1 Brown-headed Parrot (*Perocephalus fuscicapillus*), from East Africa, presented by Lady D. Prain on September 24th.

2 Mikado Pheasants (*Calophasis mikado*), from Mount Arizan, Formosa, presented by Mrs. E. J. Johnstone on September 6th.

The SECRETARY exhibited a preparation of the alimentary tract of a young Elliot's Pheasant (*Phasianus ellioti*), dissected so as to show the gut-pattern in relation to the mesentery, blood-vessels, and visceral nerves. The preparation was mounted as a transparent object in glycerine jelly, and showed how the various morphological conditions of the intestinal tract to which he had called attention (Trans. Linn. Soc., Zool. viii. p. 173) might be displayed as permanent museum objects.

*Young Woolly Opossums and Degus.*

Mr. R. I. Pocock, F.R.S., F.Z.S., Curator of Mammals, exhibited a female and three young specimens of the Woolly Opossum (*Philander laniger*), from Buenaventura in Colombia, presented by Dr. H. G. F. Spurrell, F.Z.S., and drew attention

to the rapid growth of the young. When Dr. Spurrell captured the mother, the little ones were still in the pouch. Six weeks afterwards, when they reached the Gardens, they had left the pouch for good, were about one-fourth grown, and were just beginning to feed on their own account, though mainly dependent upon their mother's milk. In another six weeks—that is to say, three months after capture—they were three-fourths their mother's size, and apparently quite capable of fending for themselves.

Mr. Pocock also exhibited two young examples of a Degu (*Octodon degus*), born from a pair from Valparaiso, presented by Mr. Walter Goodfellow, F.Z.S. The mother had a litter of four, but died from inability to give birth to a fifth. The little ones were fed by hand, and although two of them quickly died from pneumonia, the remaining two thrived and promised to do well. Like the young of all Hystricomorphous rodents, the Degus are of large size at birth and open their eyes within twenty-four hours, and are in every respect very precocious as compared with young rats. Particular attention was directed to the lateral position of the teats in the Degu, a condition which is repeated in the Viscacha and Chinchilla and the Coypu. This condition is probably an adaptation to the large size of the young, which are enabled to suck lying alongside the mother, so that they do not interfere with each other. In the Coypu, as first described by Owen, the teats are higher up the side than in the Chinchilla and the Degu, an arrangement which permits the young of that species, it has been alleged, to suck while swimming alongside their mother in the water.

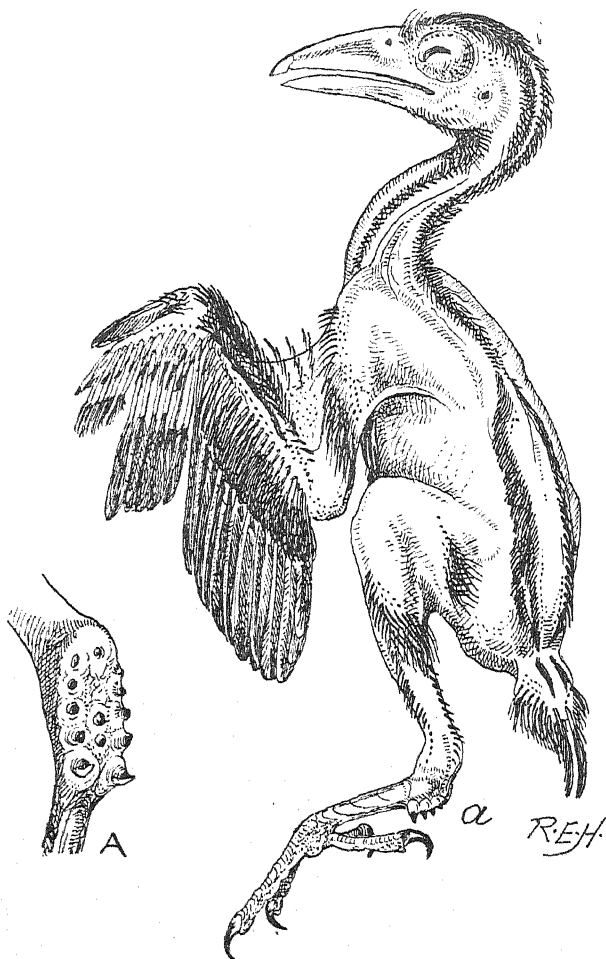
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#### *Heel-Pads in young Toucanet.*

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited a spirit-specimen of a young Toucanet (*Selenidera maculirostris*) (text-fig. 191) which had been hatched in the Society's Gardens in July, and called special attention to the well-developed serrated pads on the back of the ankle-joint or heel. This pad had been previously observed in the nestlings of Woodpeckers, Wrynecks, and Barbets, and it was only to be expected that it would be present also in the Toucans.

The use of this serrated pad, which disappears soon after the young bird leaves the nest, is doubtless to enable it to climb up the side of the hollow cavity in a tree in which it is hatched—these pads forming, as it were, a second set of claws. It is noteworthy that no such pads are found in the Parrots, which nest in similar situations to those chosen by Barbets and Toucans, but which are provided with a hooked beak which aids them in climbing.

Text-fig. 191.



Nestling of Spot-billed Toucanet (*Selenidera maculirostris*) showing feather-tracts and serrated pads ( $\alpha$ ) on metatarsal joint. A. Enlarged view of serrated pad.

*A Deep-Sea Angler-Fish, MELANOCETUS JOHNSONII.*

Mr. C. TATE REGAN, M.A., F.Z.S., exhibited a specimen of a remarkable fish, *Melanocetus johnsonii* Günth., that had been presented to the British Museum by the Hon. Walter Rothschild, F.R.S., and made the following remarks:—

“This curious fish has an enormous mouth armed with slender



pointed depressible teeth and an extraordinarily distensible stomach; it belongs to the order *Pediculati* and is a bathypelagic species, uniformly blackish in colour; like the Angler (*Lophius piscatorius*) it has the first ray of the spinous dorsal fin situated on the snout and modified into a line and bait; in this case the bait is a luminous bulb.

"The species is known from six specimens from the North Atlantic, three dredged at considerable depths by the 'Travailleur' et 'Talisman,' 'Valdivia' and 'Michael Sars' expeditions, and three in the British Museum collection. The last are from 3 to  $3\frac{3}{4}$  inches long (from snout to end of caudal fin) and include the type described by Günther (Proc. Zool. Soc. 1864, p. 301, pl. xxv.) from Madeira; this had in its stomach a partly digested Scopeloid fish (*Lampanyctus crocodilus* Risso) about 7 inches long. The second specimen was taken at the surface in  $31^{\circ}$  N. and  $37^{\circ}$  W., and had in its stomach an almost perfect *L. crocodilus* nearly 8 inches long; this was captured by Captain Charles C. Dixon, master of the bark 'Elginshire,' who also secured the fish exhibited to-night at 7 A.M. on August 27th, 1910, in  $40^{\circ} 19'$  N. and  $42^{\circ} 25'$  W. By a strange coincidence this specimen also contains a *L. crocodilus*, and judging by the anterior part of the head, which is still visible, one about 8 inches long; it is curled round into a complete circle in the stomach of the *Melanocetus*.

"Captain Dixon writes that the *Melanocetus* was still alive when captured and that from his observations he believes that it could make the 'lure' luminous or not at will. The fact that it was caught early in the morning is interesting, for it is known that at night many fishes that dwell at a depth of 300 fathoms or more may approach much nearer the surface; here the large *Lampanyctus* may have been seized and its struggles may have brought the captor still further out of its depth and rendered it helpless."

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November 11, 1913.

Dr. S. F. HARMER, M.A., F.R.S., F.Z.S.,  
in the Chair.

Mr. E. G. BOULENGER, F.Z.S., Curator of Reptiles, exhibited a quite young specimen of the Matamata Terrapin (*Chelys fimbriata*), the shell of which measured but 5 cm. in length. This specimen, the smallest yet recorded, differed from the existing descriptions of the young of this species in the under surfaces being of a bright magenta-red instead of pale yellow. Mr. Boulenger suggested that as all the young previously described were more than double the size of the specimen exhibited, red might be the normal coloration of the under surfaces as a juvenile livery.

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*Hybrid Birds.*

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited a remarkable hybrid (text-fig. 192) between a Black-winged Peacock (*Pavo nigripennis*) and a Domestic Hen (said to be a cross-bred

Text-fig. 192.

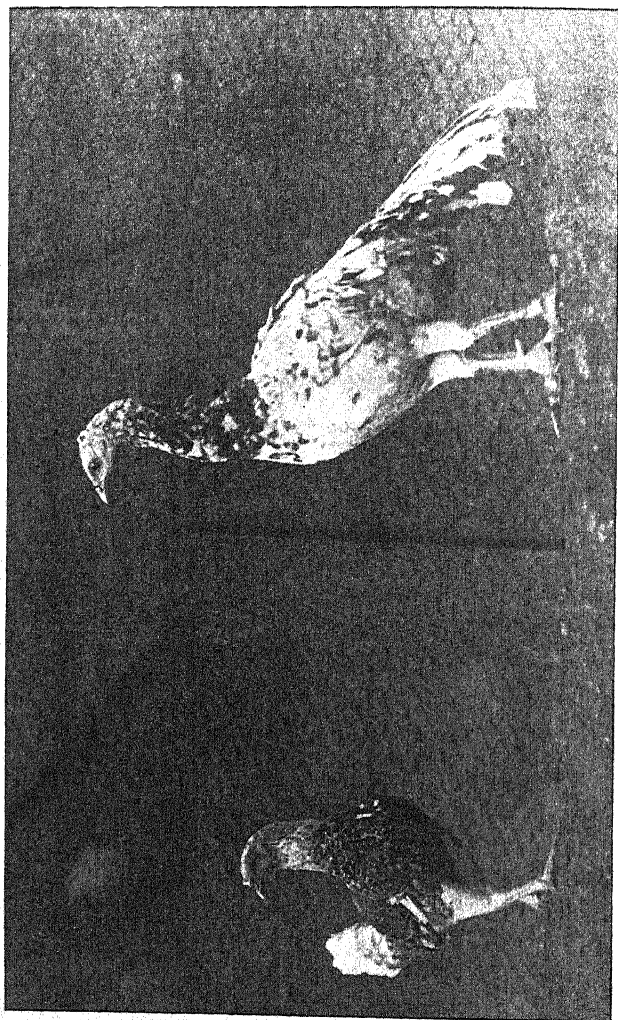


Photo. by D. Seth-Smith.

Hybrid Black-winged Peafowl, with its mother, a brown-and-white domestic hen.

game and Leghorn), which had been bred and presented to the Society by Mr. R. P. Wheadon of Ilminster. This bird was hatched in 1911 and is believed to be only the second example

of this hybrid ever produced, although hybrids between peafowl and guinea-fowl had been recorded. It was mostly white in colour, splashed, especially on the neck, with reddish brown, a colour derived from the domestic hen, its mother. It showed clearly the characters of both parents.

Mr. Seth-Smith also showed photographs, by means of lantern-slides, of a male hybrid Pheasant between *Calophasis nikado* and *C. ellioti* and of a male Jungle-fowl between *Gallus varius* and *G. gallus*.

The former had been bred in Sussex by Mrs. E. J. Johnstone, and kindly presented to the Society. It resembled a very dark-coloured Elliot's Pheasant, with the head and neck, breast, and abdomen black. The tail was black, suffused with chestnut and crossed with broad white bands.

The hybrid *Gallus*, which was one of several bred in the Gardens, was very intermediate between the two parent species. The comb was shaped like that of *G. varius*, but was slightly serrated, while the central wattle of *G. varius* was present though reduced in size, as well as the two side wattles of *G. gallus*. The neck hackles, which in *G. varius* are short and rounded, were in the hybrid moderately long as in *G. gallus*, but rounded at the ends, while the colour of these hackles as well as of the tail, was violet-purple. This bird appeared to be identical with that named *Gallus aeneus* by Temminck.

### *Dorsal Glands in Armadillos.*

(Text-figures 193-195.)

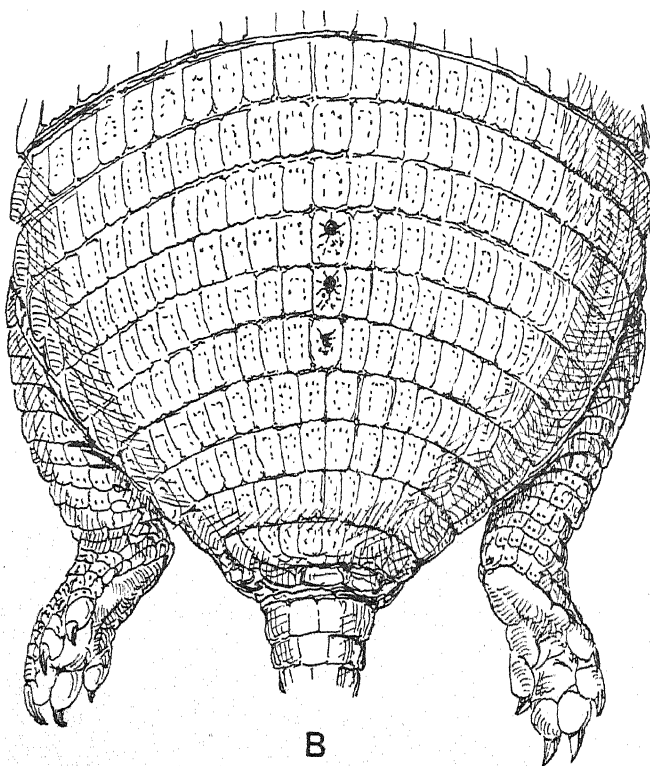
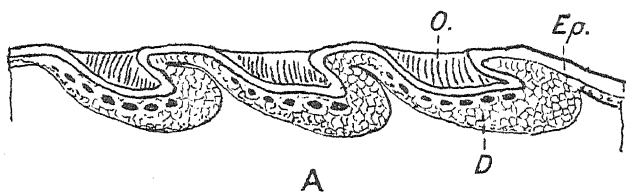
Mr. R. I. Pocock, F.R.S., F.Z.S., Curator of Mammals, exhibited some specimens of Armadillos of the genus *Euphractus*\* (formerly *Dasypus*) to show the presence of a row of glands upon the pelvic portion of the carapace, and remarked:—"In the middle line of the pelvic shield there is an unpaired series of two, three, or four scars which are ill-defined in the living animal but tolerably conspicuous in dried skins and clearly marked when the scales are removed from the osseous scutes. Their conspicuousness in museum specimens cannot have escaped the notice of systematic workers, but apparently their significance has never been investigated.

"My attention was originally drawn to them by noticing that in newly born Hairy Armadillos (*E. villosus*) there are two or three small holes, one on the fourth, a second on the fifth, and sometimes a third on the sixth row of scutes of the shield in question. At this early stage the integument is unossified and can easily be cut with a razor. A section through the holes in question shows that they are the orifices of shallow pits directed

\* According to Thomas, P. Z. S. 1911, p. 141, *Dasypus* must be transferred to the Peba Armadillos, replacing *Tatusia*.

downwards and forwards and dipping into the dermis which is especially thickened and apparently highly glandular beneath

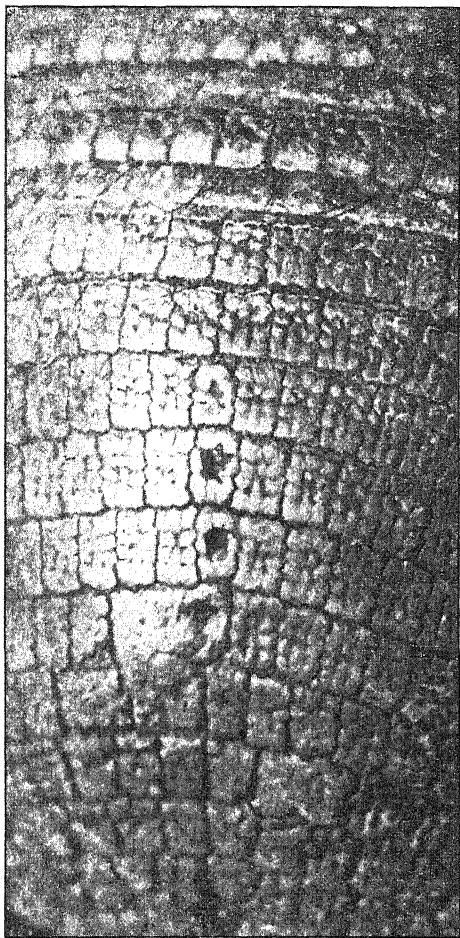
Text-fig. 193.



- A. Longitudinal section of the three glands in the newly born Hairy Armadillo (*Euphractus villosus*).  
*Ep.*, epidermis; *D*, glandular thickened dermis; *O.*, orifice of pit.
- B. Pelvic carapace of the same showing the glandular orifices on the 4th, 5th and 6th belts.

them, the topmost layer of the thickening being marked with a few spots of black pigment. The glandular nature of the pits was readily ascertained in the case of living adult armadillos of

Text-fig. 194.

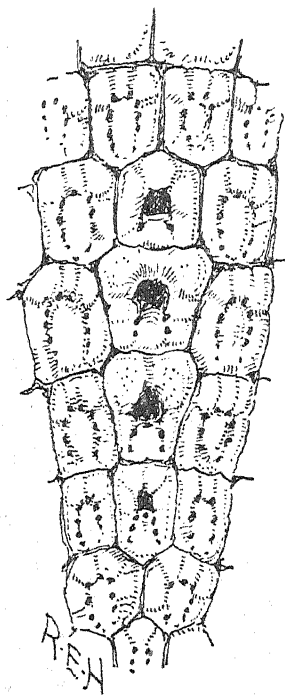


Photograph of part of the pelvic carapace of an adult living Hairy Armadillo showing the three glands on the 4th, 5th, and 6th belts. (The gland-bearing scute of the 6th belt was fractured and the pits being filled with secretion showed up more clearly than when dry.)

this species by squeezing the scutes bearing the scars and pressing from them drops of fluid with the same objectionable odour as

that which characterises these animals. Since the glands, judging from external appearances, are equally developed in adults of both sexes and appear at birth, there is no reason for thinking their function is in any way sexual. Their smell may be sufficiently nauseous to protect armadillos from enemies or it may act only as a guide enabling these animals to track each other and keep together.

Text-fig. 195.



Drawing of the central portion of the pelvic carapace of the Six-banded Armadillo (*Euphractus sexcinctus*) with four glandular pits, suggesting the origin of the pits from the enlargement and concrescence of the bristle-pores.

"When the dorsal carapace of an armadillo is stripped, cleaned and dried, the position of the glands is marked on the under side of the pelvic shield by a row of bony prominences. Each prominence represents a gland and is in reality a hollow bony pit resulting from the ossification of the dermal layer immediately beneath the gland. This at all events is the case in a carapace of *Euphractus sexcinctus* kindly lent to me by Mr. R. E. Holding. In this specimen there are seven free rings behind the scapular shield, but the seventh is not so free as those that precede it.

Following this are nine rings fused together and constituting the pelvic shield. The median glandular pits are observable upon the third, fourth, fifth and sixth of these; and the scutes which carry them are distinguished by their shape from those of the rest of the pelvic shield. The glandular pit upon the sixth ring is much smaller and shallower than the rest and is especially interesting as showing the origin of the specialized glandular areas. The scutes of the carapace in this species are covered with pores, many of which are quite small; but a varying number, generally about ten and lying in two grooves, are much larger and arranged in two longitudinal lines meeting anteriorly and forming a somewhat horseshoe-shaped pattern. That these large pores perforate the bony scutes may be seen by holding the carapace against the light.

"According to de Meijere\* these pores are bristle-pores and indicate lines of fusion between small and originally separated scutes. However that may be, there is no doubt, I think, that the glands above described result from the concentration and fusion of these rows of pores. The evidence for this is particularly strong in the case of the posterior of the four glands in *Euphractus sexcinctus* where the pores may be seen to be concentrated in the shallow central depression of the scute that bears them."

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November 25, 1913.

Prof. E. W. MACBRIDE, M.A., D.Sc., F.R.S., Vice-President,  
in the Chair.

THE SECRETARY read the following report on the additions made to the Society's Menagerie during the month of October 1913:—

The number of registered additions to the Society's Menagerie during the month of October last was 214. Of these 104 were acquired by presentation, 42 by purchase, 16 were received on deposit, 38 in exchange, and 14 were born in the Gardens.

The number of departures during the same period, by deaths and removals, was 237.

Amongst the additions special attention may be directed to:—

3 Entellus Langurs (*Presbytis entellus*), from North India, and 1 Wanderoo Macaque (*Macacus silenus*), from Malabar, presented by W. O. Danckwerts, Esq., K.C., F.Z.S., on October 14th and 24th.

1 Slater's Dog (*Canis slateri*), from the Amazons, purchased on October 2nd.

1 Mexican Tree-Porcupine (*Coendou mexicanus*) and 1 Peba

\* De Meijere, Morphol. Jahrb. xxi. pp. 316, 318 (1894).

Armadillo (*Tatusia novem-cincta*), from Mexico, purchased on October 8th and 30th.

1 Dorsal Hyrax (*Dendrohyrax dorsalis*), from Sierra Leone, presented by Mrs. A. M. Bettington on October 7th.

1 Black-backed Hangnest (*Icterus mesomelas*), from Central America, 1 Loo-Choo Jay (*Lalocitta lidthii*), from the Loo-Choo Islands, and 1 Purple-breasted Parrot (*Triclaria cyanogastra*), from S.E. Brazil, all new to the Collection, received in exchange on October 27th.

2 American Harriers (*Circus hudsonius*) and 1 Mississippi Kite (*Icterus mississippiensis*), from North America, both new to the Collection, received in exchange on October 7th.

3 Pileated Guans (*Penelope pileata*), 3 Araucuan Guans (*Ortalis araucuan*), and 2 Rufous-necked Rails (*Aramides chiricote*), from Para, all new to the Collection, presented by the Goeldi Museum on October 20th.

2 Brazilian Tortoises (*Platemys platycephala*), new to the Collection, purchased on October 15th.

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Prof. H. MAXWELL LEFROY, M.A., F.Z.S., Honorary Curator of Insects, briefly described the arrangement of the New Insect House, the progress made with the fitting-up of the interior, and the installation of and method of displaying the exhibits.

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Mr. R. H. BURNE, M.A., F.Z.S., showed some specimens of fœtal skeletons prepared by the Beale-Schultze method. The fœtus after being dehydrated is soaked in 1-3 per cent. caustic potash, and finally mounted in glycerine. By this procedure the soft parts become almost completely transparent, leaving any calcareous deposit opaque.

The specimens shown were fœtuses of the Fowl, Horse, and Man. In the Fowl attention was drawn to the three separate metatarsals that at an older stage fuse to form the single tarso-metatarsus. In the same way in the Horse the ossifying shafts of the ulna, fibula, and splint-bones could be clearly distinguished.

A specimen of the skeleton of a Star-fish (*Asterias rubens*) prepared by the same method was also exhibited.

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ABSTRACT OF THE PROCEEDINGS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.\*

May 20th, 1913.

Prof. E. A. MINCHIN, M.A., F.R.S., Vice-President,  
in the Chair.

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The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the Additions that had been made to the Society's Menagerie during the month of April 1913.

The LIBRARIAN submitted a list of dates of publication of the early parts of the Society's 'Transactions,' drawn up from the records kept by Messrs. Taylor & Francis, printers to the Society.

Mr. R. E. HOLDING exhibited a large number of specimens and photographs illustrating variations in the growth of the Antlers of Deer.

The Rev. T. R. R. STEBBING, M.A., F.R.S., F.Z.S., drew attention to Prof. F. E. Schulze's important work on zoological nomenclature, the 'Nomenclator Animalium,' giving a brief description of its objects and scope, and urging its claims for assistance from British naturalists.

Dr. R. BROOM, C.M.Z.S., read a paper "On the South African Pseudosuchian Reptile *Euparkeria* and allied Genera." Besides

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\* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

giving an account of the very completely known South African form, he also discussed the structure of the Elgin allied forms, *Ornithosuchus* and others. The group of Pseudosuchians he regarded as an extremely important primitive reptilian order, as there is good reason to believe that not only does it contain the ancestor of the Dinosaurs, but also the ancestors of the Pterodactyles and Birds. *Euparkeria* and *Ornithosuchus* are, in structure, almost Dinosaurs, and it is held that when the bipedal habit was more fully acquired the few characters not quite Dinosaurian would become Dinosaurian. Birds are held to have originated from a Pseudosuchian which, by a bipedal habit, had acquired a Dinosaur-like hind limb, and had then become arboreal in habit and acquired the peculiar power of flight.

Mr. E. G. BOULENGER, F.Z.S., Curator of Reptiles, read a paper giving an account of the experiments which he had, for the past year, been conducting on the Metamorphosis of the Mexican Axolotl (*Amblystoma tigrinum*), and gave a detailed description of the changes that take place in the course of transformation. He also exhibited a number of specimens in the perfect or Amblystome condition. The conclusions arrived at by the author, as a result of his experiments, were that, in accordance with Mlle. de Chauvin's experiments, and contrary to those of Dr. Powers, the Axolotl will, with a few exceptions, transform if placed under special conditions which force it to breathe air more frequently than usual; that starvation, irregular feeding, and temperature have no influence on the metamorphosis; that the elimination of oxygen from the water has likewise no bearing on the point, as the animal will not, under the circumstances, rise to the surface and make use of its lungs at more frequent intervals than animals placed under normal conditions.

Mr. G. E. BULLEN contributed a short paper, communicated by Mr. John Hopkinson, F.Z.S., "On some Cases of Blindness in Marine Fishes." Work hitherto performed, *e.g.* that of Hofer, de Drouin de Bouville, and others, upon the pathology of fishes has been directed largely upon species of freshwater habitat. The present author has found, in certain specific cases of blindness in marine fishes, pathological conditions similar to those described, and others with slight modifications, in several freshwater species. The examples dealt with in detail are traumatic corneal opacitis in a Conger-Eel, corneal opacitis, etc., in a Greater Weaver, and corneal opacitis and cataract in a Pollack.

Dr. R. W. SHUFELDT, C.M.Z.S., sent a paper dealing with the Patella in the Phalacrocoracidae. From a study of the patella in a number of species of this family, he had found that in adult individuals that bone was composed of the true patella solidly fused with the proximal portion of the cnemial process of the

tibio-tarsus, which became dissociated from the latter early in the life of the bird. Late in life this fusion obliterated the tendon of the ambiens muscle, which heretofore had been described as passing through the patella and persisting through life.

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The next Meeting of the Society for Scientific Business (closing the Session 1912-1913) will be held on Tuesday, June 3rd, 1913, at half-past Eight o'clock P.M., when the following communications will be made :—

EXHIBITIONS AND NOTICES.

Sir ARTHUR H. CHURCH, K.C.V.O., M.A., D.Sc., F.R.S., F.S.A.

Notes on Turacin and Turacin-bearers.

P. CHALMERS MITCHELL, M.A., D.Sc., LL.D., F.R.S., F.Z.S.

Observations on the Anatomy of the Shoe-bill (*Baleniceps rex*).

T. H. WITHERS, F.G.S.

Some Miocene Cirripedes of the Genera *Hexelasma* and *Scalpellum* from New Zealand.

Prof. ARTHUR DENDY, D.Sc., F.R.S., F.Z.S., and R. W. H. Row,

B. Sc.

The Classification and Phylogeny of the Calcareous Sponges, with a Reference List of all the described Species, systematically arranged.

Surgeon JOSEPH C. THOMPSON, U.S.N.

Contributions to the Anatomy of the Ophidia.

Prof. T. WINGATE TODD, M.B., F.R.C.S.

Observations on Osteomalacia in the Zoological Collections of Manchester and Cleveland.

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The following paper has been received :—

D. M. S. WATSON, M.Sc.

*Batrachiderpeton lineatum* Hancock & Atthey, a Coal Measure Stegocephalian.

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Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,  
*Secretary.*

ZOOLOGICAL SOCIETY OF LONDON,  
REGENT'S PARK, LONDON, N.W.

*May 27th, 1913.*



ABSTRACT OF THE PROCEEDINGS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.\*

June 3rd, 1913.

Prof. E. W. MACBRIDE, M.A., D.Sc., F.R.S., Vice-President,  
in the Chair.

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The Minutes of the last Scientific Meeting were confirmed.

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited the egg and young of the Mikado Pheasant (*Calophasis mikado*), a rare species, described first in 1906, from the mountains of Formosa. Some living specimens had been imported in 1912 by Mr. Walter Goodfellow, and the owners of these birds had entrusted the eggs to the Zoological Society, where they were being hatched.

The egg was cream coloured and very large compared with those of allied species of pheasants, being  $57 \times 41$  mm.

The incubation period proved to be twenty-eight days, instead of twenty-four as in the majority of pheasants, and the young when newly hatched were very large, and had the quill-feathers better developed than was the case in allied species.

Sir ARTHUR H. CHURCH, K.C.V.O., F.R.S., read a paper, communicated by the Secretary, entitled "Notes on Turacin and the Turacin-bearers."

This paper contains a summary of the chief facts as to the composition, properties, and occurrence of turacin, the soluble crimson pigment of the Musophagidæ. Special stress is laid upon its constancy of composition, the limitation of its occurrence to

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certain plantain-eaters, and the relation of its spectrum to the spectra of hæmoglobin and chlorophyll. Some current errors concerning turacin are corrected.

The SECRETARY, Dr. P. CHALMERS MITCHELL, F.R.S., gave an account of his observations on the Anatomy of the Shoe-bill (*Baleniceps rex*), illustrating his remarks with lantern-slides. He showed that *Baleniceps* and *Scopus* shared so many anatomical characters, and of these so many occurred also in Storks, that if the reasoning generally followed by anatomical ornithologists were adopted, *Baleniceps* and *Scopus* must be placed with Storks rather than with Herons. He submitted, however, that such a method was irrational, unless it were accompanied by a much closer scrutiny of the value of the characters than had hitherto been made or was yet possible, and that for the present *Baleniceps* must be regarded as the representative of a division equivalent to Storks and Herons. He thought also that the relation of the Steganopods to these three groups required reconsideration.

A paper on "Some Miocene Cirripedes of the genera *Hexelasma* and *Scalpellum* from New Zealand," communicated by Dr. W. T. CALMAN, F.Z.S., was read by Mr. T. H. WITHERS, F.G.S. An account is therein given of the 'gigantic Cirripede' of New Zealand, originally described as *Scalpellum aucklandicum*, of which remains have long been known to occur in the Waitemata Beds (Miocene) of Motutapu Island, Auckland Harbour. The valves of this Cirripede attain a length of 8 inches, and have been previously supposed to belong to a pedunculate form, but while Sir James Hector (1887) referred them to the genus *Scalpellum*, Prof. W. Blaxland Benham (1903) thought that they approached more closely to the genus *Pollicipes*. From a study of the original material collected by Prof. James Park (1887), it is now shown that this Cirripede is a sessile form allied to *Balanus*, and it is referred to Dr. P. P. C. Hoek's recently instituted genus *Hexelasma* (1913). A smaller undetermined species of *Hexelasma*, and a new species of *Scalpellum* (*sensu lato*), are also described. These are in the collection of the Geological Survey, New Zealand, and occur in the same beds as the 'gigantic Cirripede.'

A second new species of *Scalpellum* is founded on some valves from New Zealand, and a restoration is given, the remains being sufficient to justify their reference to the sub-genus *Arcoscalpellum* Hoek.

A paper on "The Classification and Phylogeny of the Calcareous Sponges, with a Reference List of all the known Species, systematically arranged," was received from Prof. ARTHUR DENDY, D.Sc., F.R.S., F.Z.S., and Mr. R. W. HAROLD ROW, B.Sc., F.L.S. This memoir aims at a complete revision of the genera of

Calcareous Sponges. Fifty recent genera are recognised and diagnosed, and all the described species, amounting to 433, are arranged under these genera. The rejected generic names, which are listed separately, amount to 97. The fifty accepted genera are grouped in 10 families, and Poléjaeff's subdivision into HOMOCÆLA and HETEROCÆLA is abandoned. The systematic part of the work is prefaced by a discussion on the principles of classification, and followed by a discussion on the phylogeny of the group, accompanied by a genealogical tree. The suggestions of Minchin and Bidder as to the systematic value of the position of the nucleus of the collared cell is followed up, and this position has been determined in 75 species. It appears from the evidence thus secured, taken, of course, in connection with other characters, that in the primitive family Homocelidæ the position of the nucleus is basal in some species and apical in others, but that it is not correlated with other characters so as to justify a subdivision of the family accordingly. From the Homocelidæ, however, two lines of descent have sprung, the one basinucleate and the other apicinnucleate; the former including the families Leucascidæ, Leucaltidæ, Minchinellidæ and Murrayonidæ, and the latter the Sycettidæ, Heteropiidæ, Grantiidæ, Amphoriscidæ and Lelapiidæ.

Surgeon J. C. THOMPSON, U.S.N., sent a paper, communicated by Dr. F. E. BEDDARD, M.A., F.R.S., F.Z.S., containing contributions to the Anatomy of the Ophidia.

The SECRETARY communicated a paper by Prof. T. WINGATE TODD, M.B., F.R.C.S., entitled "Observations on Osteomalacia in the Zoological Collections of Manchester and Cleveland."

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This Meeting closes the Session 1912-1913. The next Meeting of the Society for Scientific Business will be held on Tuesday, October 28th, 1913, at half-past Eight o'clock P.M.

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The following papers have been received :—

1. D. M. S. WATSON, M.Sc.

*Batrachiderpeton lineatum* Hancock & Atthey, a Coal-Measure Stegocephalian.

2. R. W. PALMER, B.Sc.

The Brain and Brain-case of a fossil Ungulate of the Genus  
*Anoplotherium*.

3. FRÉDÉRIC WILMET.

Notice sur l'*Okapia johnstoni*, dont l'espèce s'est retrouvée  
intacte dans une forêt commune à l'Ituri et à l'Uellé.

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Communications intended for the Scientific Meetings should  
be addressed to

P. CHALMERS MITCHELL,  
*Secretary.*

ZOOLOGICAL SOCIETY OF LONDON,  
REGENT'S PARK, LONDON, N.W.  
*June 10th, 1913.*

ABSTRACT OF THE PROCEEDINGS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.\*

October 28th, 1913.

Prof. E. A. MINCHIN, M.A., F.R.S., F.Z.S., Vice-President,  
in the Chair.

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The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the Additions made to the Society's Menagerie during the months May to September, 1913.

The SECRETARY exhibited a preparation of the alimentary tract of a young Elliot's Pheasant (*Phasianus ellioti*), dissected so as to show the gut-pattern in relation to the mesentery, blood-vessels, and visceral nerves. The preparation was mounted as a transparent object in glycerine jelly, and showed how the various morphological conditions of the intestinal tract to which he had called attention (Trans. Linn. Soc., Zool. viii. p. 173) might be displayed as permanent museum objects.

Mr. R. I. Pocock, F.R.S., F.Z.S., Curator of Mammals, exhibited a female and three young specimens of the Woolly Opossum (*Philander laniger*), from Buenaventura in Colombia, presented by Dr. H. G. F. Spurrell, F.Z.S., and drew attention to the rapid growth of the young. When Dr. Spurrell captured the mother, the little ones were still in the pouch. Six weeks afterwards, when they reached the Gardens, they had left the pouch for good, were about one-fourth grown, and were just beginning to feed on their own account, though

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mainly dependent upon their mother's milk. In another six weeks—that is to say, three months after capture—they were three-fourths their mother's size, and apparently quite capable of fending for themselves.

Mr. Pocock also exhibited two young examples of a Degu (*Octodon degus*), born from a pair from Valparaiso, presented by Mr. Walter Goodfellow, F.Z.S. The mother had a litter of four, but died from inability to give birth to a fifth. The little ones were fed by hand, and although two of them quickly died from pneumonia, the remaining two thrived and promised to do well. Like the young of all Hystricomorphous rodents, the Degus are of large size at birth and open their eyes within twenty-four hours, and are in every respect very precocious as compared with young rats. Particular attention was directed to the lateral position of the teats in the Degu, a condition which is repeated in the Viscacha and Chinchilla and the Coypu. This condition is probably an adaptation to the large size of the young, which are enabled to suck lying alongside the mother, so that they do not interfere with each other. In the Coypu, as first described by Owen, the teats are higher up the side than in the Chinchilla and the Degu, an arrangement which permits the young of that species, it has been alleged, to suck while swimming alongside their mother in the water.

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited a spirit-specimen of a young Toucanet (*Selenidera maculirostris*) which had been hatched in the Society's Gardens in July, and called special attention to the well-developed serrated pads on the back of the ankle-joint or heel. This pad had been previously observed in the nestlings of Woodpeckers, Wrynecks, and Barbets, and it was only to be expected that it would be present also in the Toucans.

The use of this serrated pad, which disappears soon after the young bird leaves the nest, is doubtless to enable it to climb up the side of the hollow cavity in a tree in which it is hatched—these pads forming, as it were, a second set of claws. It is noteworthy that no such pads are found in the Parrots, which nest in similar situations to those chosen by Barbets and Toucans, but which are provided with a hooked beak which aids them in climbing.

Mr. C. TATE REGAN, M.A., F.Z.S., exhibited a specimen of *Melanocetus johnsonii* Günther, a curious fish having an enormous mouth armed with slender, pointed, depressible teeth and an extraordinarily distensible stomach. It has the first ray of the spinous dorsal fin situated on the snout and modified into a line and bait, the latter being a luminous bulb.

Dr. F. E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society, read a paper on the anatomy and systematic arrangement of the Cestodea, in which he described a new genus and species of Tapeworms from the Double-striped Thicknee (*Edicnemus bistrictus*).

Dr. F. A. BATHER, M.A., F.R.S., F.Z.S., read a paper entitled "The Fossil Crinoids referred to *Hypocrinus* Beyrich." The two specimens of *Hypocrinus schneideri* Beyr. described by Beyrich and Rothpletz respectively are redescribed and refigured. The structure of the genus is shown to agree with that of the Devonian family Gasterocomidae, the content of which is discussed; but it is suggested that in this case and in that of "*Lecythiocrinus*" *adamsi* the distinctive features may have been independently acquired.

The holotype of *Hypocrinus piriformis* Rothpletz is redescribed and refigured, and proved to be no *Hypocrinus*. It is thought to be a highly modified descendant of the Taxocrinidae, by way of such a genus as *Cydonocrinus*. The left posterior radial appears to have borne a large arm, but the other arms are more or less atrophied, and the right posterior radial has almost disappeared.

A paper on "*Batrachiderpeton lineatum* Hancock & Atthey, a Coal-Measure Stegocephalian," communicated by Prof. J. P. HILL, D.Sc., F.R.S., F.Z.S., was read by Mr. D. M. S. WATSON, M.Sc. It contained the description of the skull, lower jaw, and pectoral girdle of this species, based on a series of specimens in the Newcastle Museum, derived from the Low Main Seam of Newsham Colliery.

A paper, communicated by Dr. C. W. ANDREWS, F.R.S., F.Z.S., was received from Mr. R. W. PALMER, M.Sc., entitled "The Brain and Brain-Case of a Fossil Ungulate of the Genus *Anoplotherium*," in which a cranium from the Phosphorites of Quercy, together with an exceptionally perfect and well-marked brain-cast obtained from it, were described from material in the British Museum collections.

The next Meeting of the Society for Scientific Business will be held on Tuesday, November 11th, 1913, at half-past Eight o'clock P.M., when the following communications will be made :—

EXHIBITIONS AND NOTICES.

W. T. CALMAN, D.Sc., F.Z.S.

On Freshwater Decapod Crustacea (Families Potamonidae and Palaemonidae) collected in Madagascar by the Hon. Paul A. Methuen.

G. A. BOULENGER, F.R.S., F.Z.S.

On a Collection of Reptiles and Batrachians made by Dr. H. G. F. Spurrell, F.Z.S., in the Colombian Choco.

C. TATE REGAN, M.A., F.Z.S.

A Revision of the Cyprinodont Fishes of the Subfamily Pæciliinae.

Prof. W. N. PARKER, Ph.D., F.Z.S.

Sponges in Waterworks.

Prof. J. PLAYFAIR McMURRICH, C.M.Z.S.

On Two new Actinians from the Coast of British Columbia.

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The following papers have been received :—

ØRJAN OLSEN.

On the External Characters and Biology of Bryde's Whale, a new Rorqual from the Coast of South Africa.

MISS M. V. LEBOUR, M.Sc.

A new Species of Trematodes of the Genus *Lechriorchis* from the Dark Green Snake (*Zamenis gemonensis*).

T. H. WITHERS, F.G.S.

Cirripedes from the Cenomanian Chalk Marl of Cambridge.



F. F. LAIDLAW, M.A., F.Z.S.

Contributions to a Study of the Dragon-fly Fauna of Borneo.  
—Part II. The Gomphinae and Chlorogomphinae.

Surgeon JOSEPH C. THOMPSON, U.S.N.

Further Contributions to the Anatomy of the Ophidia.

P. CHALMERS MITCHELL, M.A., D.Sc., LL.D., F.R.S., F.Z.S.

The Peroneal Muscles in Birds.

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Communications intended for the Scientific Meetings should  
be addressed to

P. CHALMERS MITCHELL,

*Secretary.*

ZOOLOGICAL SOCIETY OF LONDON,  
REGENT'S PARK, LONDON, N.W.

*November 4th, 1913.*



ABSTRACT OF THE PROCEEDINGS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.\*

November 11th, 1913.

Dr. S. F. HARMER, M.A., F.R.S., F.Z.S., in the Chair.

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The Minutes of the last Scientific Meeting were confirmed.

Mr. R. I. Pocock, F.R.S., F.Z.S., Curator of Mammals, exhibited a newly-born example of the Hairy Armadillo (*Euphractus villosus*) and the dried shell of a Six-banded Armadillo (*E. sexcinctus*), showing the presence of a series of from two to four small orifices in the middle line of the pelvic shield; and explained that the orifices are the apertures of shallow invaginations of the epidermis dipping down into the dermis, which is specially thickened and glandular immediately beneath them. In the living animal drops of malodorous fluid can be squeezed from the orifices of these glands.

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited a remarkable hybrid between a Black-winged Peacock and a domestic hen (cross-bred game and Leghorn) which had been bred by Mr. R. P. Wheadon of Ilminster in 1911. This bird was believed to be only the second example of this hybrid ever produced, although a hybrid between a peafowl and a guinea-fowl had been recorded (Hocker, J. f. O. 1870, p. 152).

The hybrid was mostly white in colour, splashed, especially on the neck, with reddish brown, a colour derived from the domestic hen, its mother. It showed clearly the characters of both parents.

Mr. Seth-Smith also showed photographs of a hybrid Pheasant between *Calophasis mikado* and *C. ellioti*, and of a Jungle-fowl between *Gallus varius* and *G. gallus*. The latter bird, which had been bred in the Society's Gardens, corresponded to the description of the bird described by Temminck as *Gallus aneus*.

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Mr. E. G. BOULENGER, F.Z.S., Curator of Reptiles, exhibited a quite young specimen of the Matamata Terrapin (*Chelys fimbriata*), the shell of which measured but 5 cm. in length. This specimen, the smallest yet recorded, differed from the existing descriptions of the young of this species in the under surfaces being of a bright magenta-red instead of pale yellow. Mr. Boulenger suggested that as all the young previously described were more than double the size of the specimen exhibited, red might be the normal coloration of the under surfaces as a juvenile livery.

Dr. W. T. CALMAN, F.Z.S., read a paper on Freshwater Decapod Crustacea (families Potamonidæ and Palæmonidæ) collected in Madagascar by the Hon. Paul A. Methuen, in which one new species of *Potamon* and five varietal forms of *P. madagascariense* were described. It is suggested that the River-Crabs of Madagascar may have had an autochthonous origin from some form resembling *P. madagascariense*. No clear affinities can be traced with the Potamonidæ of Africa or of Peninsular India, but it is pointed out that in the present state of knowledge the River-Crabs appear to be a hazardous subject for zoogeographical speculation.

Among the Palæmonidæ the most interesting is the species described by Hilgendorf as "*Bithynis* ? *hildebrandti*," which is figured for the first time. Evidence is brought forward to show that the species has no close affinity with the *Bithynis gaudichaudi* of Chili and Peru, and that the single character which led to its being referred to *Bithynis* is a matter of individual variation.

Mr. G. A. BOULENGER, F.R.S., F.Z.S., gave an account of a collection of Reptiles and Batrachians made by Dr. Spurrell, F.Z.S., in the Colombian Choco and presented by him to the British Museum. The series of specimens was of great interest, and contained several new species.

Mr. C. TATE REGAN, M.A., F.Z.S., read a paper entitled "A Revision of the Cyprinodont Fishes of the Subfamily Pœciliinæ." A number of new genera were defined and several new species were described; the structure of the intromittent organ was found to be of great systematic importance.

A paper received from Prof. W. N. PARKER, Ph.D., F.Z.S., gave an account of some investigations made on a growth of *Spongilla lacustris* in the Cardiff Waterworks system, and described the methods adopted to eradicate the sponge from the infected areas.

Prof. J. PLAYFAIR McMURRICH, C.M.Z.S., communicated a paper in which he described two new species of Actinians from the coast of British Columbia. These specimens probably represented stages of a single species, and belonged to a group hitherto not recorded from the west coast of America.

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The next Meeting of the Society for Scientific Business will be held on Tuesday, November 25th, 1913, at half-past Eight o'clock P.M., when the following communications will be made :—

EXHIBITIONS AND NOTICES.

ØRJAN OLSEN,

On the External Characters and Biology of Bryde's Whale, a new Rorqual from the Coast of South Africa.

Miss M. V. LEBOUR, M.Sc.

A new Species of Trematodes of the Genus *Lechriorchis* from the Dark Green Snake (*Zamenis gemdriensis*).

T. H. WITHERS, F.G.S.

Cirripedes from the Cenomanian Chalk Marl of Cambridge

P. CHALMERS MITCHELL, M.A., D.Sc., LL.D., F.R.S., F.Z.S.

The Peroneal Muscles in Birds.

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The following papers have been received :—

F. F. LAIDLAW, M.A., F.Z.S.

Contributions to a Study of the Dragon-fly Fauna of Borneo.  
—Part II. The Gomphinae and Chlorogomphinae.

Surgeon JOSEPH C. THOMPSON, U.S.N.

Further Contributions to the Anatomy of the Ophidia.

H. C. CHADWICK, A.L.S.

Note on an imperfectly-developed Specimen of *Echinus esculentus*.

G. A. BOULENGER, F.R.S., F.Z.S.

An Annotated List of the Reptiles and Batrachians collected by the British Ornithologists' Union Expedition and the Wollaston Expedition in Dutch New Guinea.

C. F. U. MEER, M.Sc., F.L.S., F.Z.S.

The Possible Connection between Spindle-length and Cell-volume.

WILLIAM NICOLL, M.A., D.Sc., M.D., F.Z.S.

Trematode Parasites from Animals dying in the Zoological Society's Gardens during 1911-1912.

F. E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S.

Contributions to the Anatomy and Systematic Arrangement of the Cestoidea.—XII. Further Observations upon the Genus *Urocystidium* Beddard.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

*Secretary.*

ZOOLOGICAL SOCIETY OF LONDON,

REGENT'S PARK, LONDON, N.W.

November 18th, 1913.

ABSTRACT OF THE PROCEEDINGS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.\*

November 25th, 1913.

Prof. E. W. MACBRIDE, M.A., D.Sc., F.R.S., Vice-President,  
in the Chair.

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The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the Additions made to the Society's Menagerie during the month of October, 1913.

Mr. R. H. BURNE, M.A., F.Z.S., showed some specimens of foetal skeletons prepared by the Beale-Schultze method. The foetus after being dehydrated is soaked in 1-3 per cent. caustic potash and finally mounted in glycerine. By this procedure the soft parts become almost completely transparent, leaving any calcareous deposit opaque.

The specimens shown were foetuses of the Fowl, Horse, and Man. In the Fowl attention was drawn to the three separate metatarsals that at an older stage fuse to form the single tarso-metatarsus. In the same way in the Horse, the ossifying shafts of the ulna, fibula, and splint-bones could be clearly distinguished.

A specimen of the skeleton of a Starfish (*Asterias rubens*), prepared by the same method, was also exhibited.

Prof. H. MAXWELL LEFROY, F.Z.S., Hon. Curator of the Insect House, briefly described the arrangement of this new building, the progress made with the fitting-up of the interior, and the installation of and method of displaying the exhibits.

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A paper received from Mr. ØRJAN OLSEN, and communicated by the Secretary, contained the description of a new *Borqual* from the Coast of South Africa and gave a detailed account of its external characters, biology, and distribution.

MISS MARIE V. LEBOUR, M.Sc., presented a paper, communicated by the Secretary, in which she described a new species of Trematodes of the genus *Lecleriorchis*, found in the body cavity of a Dark Green Snake (*Zamenis gemmonensis*) that had died in the Society's Gardens.

MR. T. H. WITHERS, F.G.S., contributed a paper, communicated by Dr. W. T. Calman, F.Z.S., based upon a large series of Cirripede remains from the Cenomanian Chalk Marl in the neighbourhood of Cambridge. The greater number of the specimens are referred to two species of the family Pollicipedidae, and add materially to our knowledge of the phylogeny of the pedunculated Cirripedes. Both forms are remarkable for their advanced form of scutum, in which the umbo is sub-central, and show that the transition of the scutal umbo from an apical to a sub-central position was acquired independently by unrelated forms in distinct lines of development.

THE SECRETARY, DR. P. CHALMERS MITCHELL, M.A., F.R.S., F.Z.S., read a communication on "The Peroneal Muscles in Birds." Dr. Mitchell had dissected these muscles in over 300 birds, and believed that he was able to give a nearly exhaustive account of the varieties of form presented by these structures. The paper described the peroneal muscles in *Chauna chavaria*, and gave a systematic account of the conditions in the different Avian groups which could all be represented as derivatives of the *Chauna* condition by loss of certain portions and increased development of other portions. It was difficult to interpret the changes in terms of function, family-relationship appearing to be more important in this respect than habit. The paper discussed the very few cases of want of conformity between the peroneal muscles and the place assigned in the best-founded systems of classification. It also dealt with the use of such anatomical characters in systematic classification, and showed that there was a definite relation between specialized conditions of the peroneal muscles and specialized conditions of the Avian structure generally.



The next Meeting of the Society for Scientific Business will be held on Tuesday, February 3rd, 1914, at half-past Eight o'clock P.M., when the following communications will be made:—

EXHIBITIONS AND NOTICES.

G. A. BOULENGER, F.R.S., F.Z.S.

An Annotated List of the Reptiles and Batrachians collected by the British Ornithologists' Union Expedition and the Wollaston Expedition in Dutch New Guinea.

F. E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S.

Contributions to the Anatomy and Systematic Arrangement of the Cestoidea.—XII. Further Observations upon the Genus *Urocystidium* Beddard.

H. G. PLIMMER, F.R.S., F.Z.S.

Report on the Deaths which occurred in the Zoological Gardens during 1913.

The following papers have been received:—

F. F. LAIDLAW, M.A., F.Z.S.

Contributions to a Study of the Dragon-fly Fauna of Borneo.  
—Part II. The Gomphinae and Chlorogomphinae.

Surgeon JOSEPH C. THOMPSON, U.S.N.

Further Contributions to the Anatomy of the Ophidia.

H. C. CHADWICK, A.L.S.

Note on an imperfectly-developed Specimen of *Echinus esculentus*.

C. F. U. MEEK, M.Sc., F.L.S., F.Z.S.

The Possible Connection between Spindle-length and Cell-volume.

WILLIAM NICOLL, M.A., D.Sc., M.D., F.Z.S.

Trematode Parasites from Animals dying in the Zoological Society's Gardens during 1911-1912.

F. J. MEGGITT, M.Sc

The Structure and Life-History of a Tapeworm (*Ichthyotania  
filiicollis* Rud.) parasitic in the Stickleback.

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Communications intended for the Scientific Meetings should  
be addressed to

P. CHALMERS MITCHELL,

*Secretary.*

ZOOLOGICAL SOCIETY OF LONDON,  
REGENT'S PARK, LONDON, N.W.

*December 2nd, 1913.*



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